

# FARMERS' MANUAL OF *Crop Drying*

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AGRICULTURAL DEVELOPMENT DIVISION OF THE LENNOX FURNACE COMPANY  
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## TABLE OF CONTENTS

Definitions of common terms . . . . .	page 3
Foreword . . . . .	page 4
Crop drying comes of age . . . . .	page 5
Advantages of mechanical drying . . . . .	page 6
How hay losses occur . . . . .	page 7
How to prevent hay losses . . . . .	page 8
Corn losses and how to prevent them . . . . .	page 10
Crop drying methods . . . . .	page 12
<b>HAY DRYING</b>	
Hay drying with unheated air . . . . .	page 13
Hay drying with heated air . . . . .	page 17
Hay drying in batches . . . . .	page 19
<b>GRAIN DRYING</b>	
Grain drying with unheated air . . . . .	pages 20 30
Grain drying with heated air . . . . .	pages 24 32
Grain drying in batch bins . . . . .	page 25
Lennox Fans . . . . .	page 33
Lennox Cropmaster . . . . .	pages 17 34
Lennox Batch Bins . . . . .	pages 27 28 34
Lennox Wagon Box Bottoms For Drying . . . . .	page 34
Appendix of additional data . . . . .	page 35

## DEFINITIONS OF COMMON TERMS USED IN MECHANICAL DRYING OF CROPS

<b>MOISTURE CONTENT . . . . .</b>	A term used to describe the wetness of a crop. Moisture content is expressed in the percentage of water (by weight) in a crop. Example: 100 Pounds of hay of which 25 pounds are moisture and 75 pounds are dry hay, has a moisture content of 25%.
<b>RELATIVE HUMIDITY . . . . .</b>	A term that describes the moisture content of air at a given temperature. Example: If air at 70° holds 50% of the moisture that air at 70° can hold, it is said to have a relative humidity of 50%.
<b>CFM . . . . .</b>	Refers to Cubic Feet Per Minute. It is the common measurement of the volume of air flow.
<b>BTU . . . . .</b>	British Thermal Unit. A commonly used measurement for amount of heat. It is usually expressed in BTU per hour (Btuh). A BTU is the amount of heat required to raise one pound of water one degree Fahrenheit. (It is about the amount of heat given off when a kitchen match is completely burned.)

### STANDARD MEASURES\*

- 1 bushel of corn equals 56 pounds.
- 1 bushel of wheat equals 60 pounds.
- 1 bushel of oats equals 32 pounds.
- 1 bushel of rye equals 56 pounds.
- 1 bushel of flax equals 56 pounds.

\*These are considered the normal weights, but may differ in various parts of the country and with varying moisture content. In case of doubt, see your county farm agent or local grain market.



## FOREWORD

### —to leading farmers everywhere

As a farmer, your greatest friend and your worst enemy is the same thing . . . nature. Nature can make you or break you. And through the years, the farmer's role has become one of importance and great satisfaction because he has learned to increase the "make" in nature while reducing the "break."

The problem of "beating" nature is a tough one. But the farmer has proven his ability to do it. He has done it by using better and better tools and methods and by becoming a good businessman. The production records stand as evidence.

Not only is the farmer in competition with nature, but he is competing with other farmers, too. And the man who produces better products with greater efficiency is the man who will come out on top.

*Now, new methods of drying crops open wonderful opportunities to competitive farmers like you who are not content to be at the mercy of nature when it comes to getting your harvest in . . . who are not content to watch your competitors walk off with the premium prices. It is for you that this booklet has been prepared.*

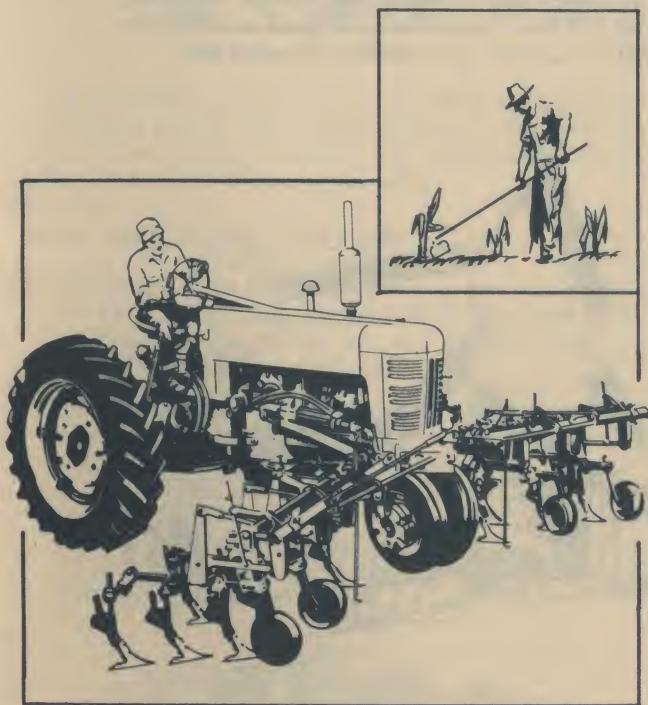
Information and data for this booklet have been supplied by the United States Department of Agriculture, several state universities and colleges, the Butler Manufacturing Company, ARMO Steel Corporation, Crop Dryer Manufacturers Association, and the Agricultural Development Division of The Lennox Furnace Company.

## CROP DRYING COMES OF AGE

The history of crop drying is as old as the history of agriculture. That's because crops that are not consumed immediately after harvest must be preserved for future use. Drying has always been the most popular and practical method of preservation.

By taking most of the moisture from the crop, the growth of mold and decay bacteria is prevented. When this is done properly, most of the crop's food value remains, but the crop can be stored safely without danger of mold and decay.

Until very recent years, methods of crop drying have lagged far behind the progress of agriculture in general. During the thousands of years that man has been learning the arts of plowing, cultivation, irrigation, fertilization, horticulture and reaping, the method of drying crops has remained much the same. And the majority of crops are still dried just as they were thousands of years ago . . . by leaving the crop out in the open for nature to do the drying job.



Certain techniques, such as shocking grain and wind-rowing hay, were developed through the years. But still the farmer was at the mercy of the weather. Perhaps his crop would dry with only the normal field losses. Perhaps bad weather would lengthen the drying process and spoil the crop's quality. Perhaps it would all be ruined. Most farmers still run those risks and take the losses. Others do something about it.



Mechanical drying of crops is the answer to the ancient crop drying problem . . . just as machinery has been the answer to other farm production problems. The idea of mechanical drying is not new. U.S. patents on crop drying structures were taken out as early as 1847. But not until recently has it become practical.

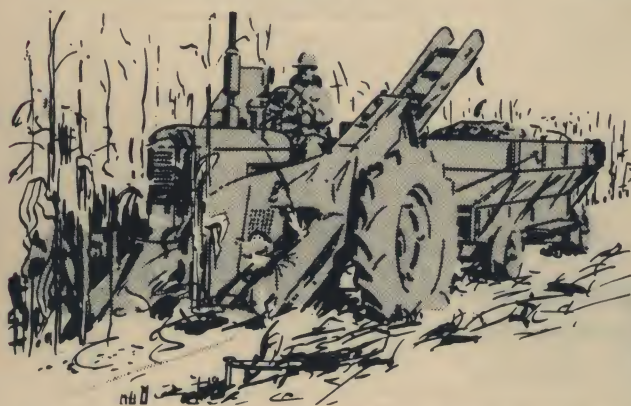
Simply stated, mechanical drop drying is done by forcing air (either heated or unheated) through the crop. The air absorbs moisture from the crop and carries it away. This operation usually takes place in a building or a bin so that the crop is protected from the weather.



## WHAT ARE THE ADVANTAGES OF MECHANICAL DRYING?

When you use mechanical drying the outstanding advantage you have over field drying is *greater profit*. And what better reason could the businessman farmer want? When you take crop drying out of the hands of the weatherman and control it yourself, you will profit in many ways. Here are some of them:

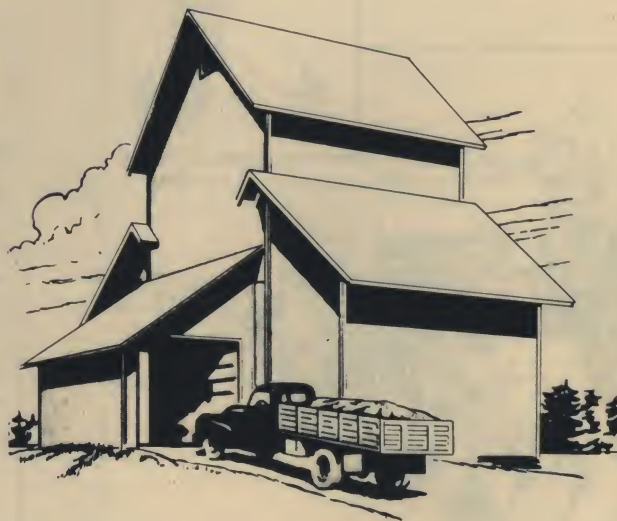
- 1 You will profit because you can harvest your crop when it is at prime condition . . . when it is at its peak food value content. You need not wait for it to lose moisture content naturally. You need not wait for what *might* be good drying weather.
- 2 You will profit because you will reduce field losses. When you harvest your crop at its prime your harvesting machinery is most efficient because the machinery was designed to work best on erect stands of corn, hay, wheat, etc. at a fairly high moisture content. By waiting for the crop to dry naturally, you run the risk of loss to wind and rain. Flattened fields of grain or hay just cannot be harvested efficiently, as you well know.



- 3 You will profit because you will get your crop under cover sooner. This prevents loss of food value to the weather. Sun and rain bleach and soak away much food value such as protein. Rain also causes mold and loss of leaves and kernels. So, whether you are selling your crop or feeding it, it's worth more when you protect it from the weather by mechanical drying.



- 4 You will profit because the crop will be protected from mold and vermin sooner. It will be dried evenly and to the exact moisture content you need for best storage.
- 5 You will profit because your crops will be dried sooner than those dried in the field. Thus, you can sell at higher prices before the market is flooded. Or you will have put the crop in good condition for storage so that you can hold it until prices rise.



- 6 You will profit because you will save time and work. Weather need not upset your crop drying plans. You can schedule your work. Crops can be harvested and fields cleared for the next farming operation without waiting and wondering if the crop will be dry in time.

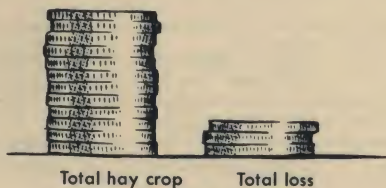


## LET'S GET DOWN TO FACTS

The six ways to profit from mechanical drying apply to most crops . . . hay of all kinds . . . all types of small grains . . . corn . . . peanuts and dozens of other foods. For examples of actual savings we will consider two common crops, hay and corn.

## THE CASE FOR HAY DRYING

Hay is one of our most important crops. Any farmer who feeds livestock knows that. In 1949 hay was the major crop in 19 states, second in 16 states. And in 1951 the U.S. hay crop was valued at more than TWO BILLION DOLLARS. Yet the figure would have been 2½ billion if hay losses could have been prevented. Farmers lost \$500,000,000 that year (and approximately that much every year) because of hay losses suffered between the time the hay was cut and the time it was fed.



In percentage, 25% of hay's feed value is lost before the animal gets it. That's quite a loss . . . one that has to be made up with expensive feed supplements. Let's take a look at how those losses occur.

## HOW HAY LOSSES OCCUR:

- 1 *By harvesting at the wrong time.* Farmers know when to harvest, but wet weather often interferes with cutting and field curing hay at the proper time . . . when the hay is at its peak feed value.
- 2 *Loss in the field due to rain.* Rain tends to shatter and strip leaves and stems. It leaches away the valuable nutrients which are most easily digested. A report from the New Jersey Agricultural Experiment Station says, "clover and alfalfa can lose from 25% to 50% of its dry matter due to the action of rain and moisture." Much of this loss is in vital carotene and protein.



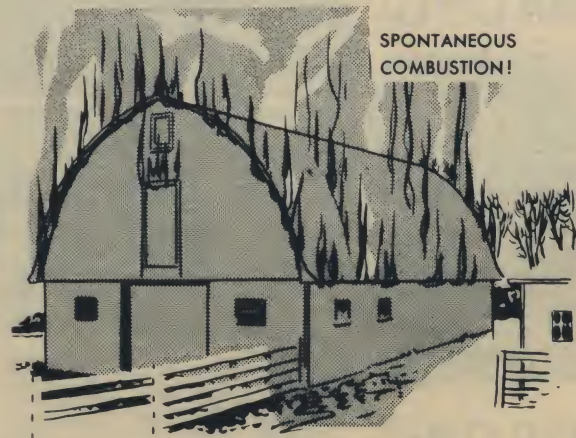
- 3 *When hay gets too dry in the field.* This leads to loss of leaves and much food value. According to the 1950-51 Yearbook of Agriculture, "probably the biggest agricultural loss in this country occurs when freshly cut grass or alfalfa is allowed to dry slowly in the fields . . . carotene, one of the important feed elements in fresh alfalfa, is partially destroyed if hay is field cured. The loss may amount to 50% to 80% of the total carotene present in the green plant."

Because of weather hazards, enough protein is lost each year to supply the entire protein requirement for 7½ million cows for six months. Pity the farmers who are losing that tremendous amount of feed, and who are buying extra protein supplement. Are you one of them?



Also, rain makes it necessary to rake hay more often. This increases labor, as well as to cause more loss of valuable leaves. A report from the University of Connecticut states that, in Connecticut during an average June, 37% of the hay will be rained on once, 29% will be rained on more than once . . . in July 32% of the hay will be rained on once and 11% will receive rain two or more times. This could result in a total loss.

- 4 *Losses due to fire.* Storing wet hay without forced air ventilation and drying is extremely dangerous. Spontaneous combustion in hay mows caused an estimated 20 million dollar loss in 1950.





## HOW TO PREVENT HAY LOSSES

Modern methods of mechanically drying hay do much to prevent the huge loss that is suffered annually because of centuries-old methods of curing hay.

*First*, hay can be harvested with less regard for the weather. It can be cut and brought in at the proper stage of maturity (see chart at right).

*Second*, the hay is exposed to weather for a much shorter period of time. Rain and sun do not get much chance to rob it of feed value, or destroy it altogether. (The United States Department of Agriculture has five year averages showing that artificially dried hay is exposed to the weather only 38% as long as field cured hay.)

*Third*, less hay is lost in the harvest because leaves and small stems stay on while the hay is still fairly fresh. The most valuable part of the hay is saved. This point alone can mean 10% to 15% more hay harvested, according to Michigan State College.

**DURING GOOD WEATHER MOST HAY IS DOWN TO 35% TO 45% MOISTURE 6 HOURS AFTER CUTTING. IT IS THEN READY TO BE TAKEN IN FOR MECHANICAL DRYING AND CAN BE HANDLED WITHOUT LOSS OF LEAVES.**

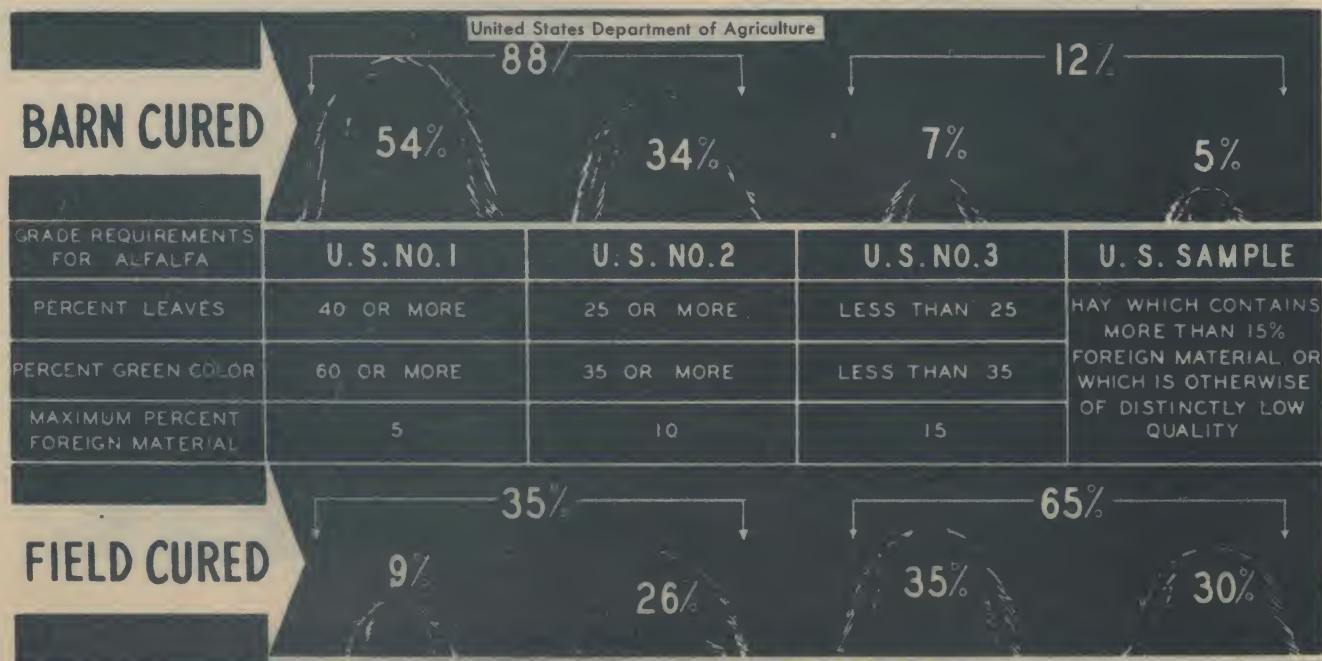
*Fourth*, mechanical drying saves man-hours. Windrow turning is eliminated. Work can continue during damp weather. Haying can be planned to fit in with other work.

*Fifth*, mechanically cured hay has higher food value than even the best field cured hay. It has better color, is less dusty, and mold can be better controlled. Table XXI, page 37

*Sixth*. Forcing air through the hay prevents spontaneous combustion. The air creates evaporation which in turn keeps the hay cooled to a safe temperature. Field cured hay is not always evenly dried . . . when put in the mow, there might be spots where the oxidizing effect of moisture will create enough heat to start a blaze.

## WHEN TO CUT HAY FOR MAXIMUM YIELD, BEST NUTRITION

CROP	WHEN TO CUT
Alfalfa	At $\frac{1}{10}$ to $\frac{1}{4}$ bloom
Alsike Clover	Full bloom
Crimson Clover	When first flowers fade at base
Sweet Clover	At beginning of bloom
Red Clover Mammoth Clover	At $\frac{1}{2}$ to full bloom
Cowpeas	When first pods mature
Annual Lespedeza	Full bloom or not over 15" tall. Or 30 days before bloom if a good following seed crop is desired.
Lespedeza Sericea	Before bloom—not over 20" tall.
Soybean Hay	When beans are almost fully developed; lower leaves yellowing.
Brome Grass	Just after full bloom.
Johnson Grass	When heads start to emerge; before $\frac{1}{4}$ of heads emerge.
Prairie Grass	Before dry weather or before plants start turning brown due to maturity.
Sudan Grass	When heading out. Not later than early bloom.
Timothy	Full-headed to early bloom.
Both kinds of Vetch	When pods are well-developed.





## SAVE MONEY BY SAVING LEAVES—THROUGH MECHANICAL DRYING

As you know, the leaves of hay contain the most food value. When leaves are lost, the hay loses much of its nutritional value. And many leaves are lost when hay is left in the field to dry and is then handled after it is dry. By taking the hay in at a high moisture content, very few leaves are lost. And by drying mechanically, they are more palatable and contain more nutrients than field-dried hay.

If hay, when it is cut, is 50% leaves by weight and if

the hay that is fed is only 30% leaves by weight, the usable yield has dropped drastically. It would be like reducing a 3-ton per acre yield to only a little over 2 tons. The cost of buying feed supplements to replace that loss would be about \$37.00 for each acre harvested. The cost of replacing the loss from a 20-acre field would be approximately \$740.00! Mechanical drying can save most of those lost leaves, as the following charts illustrate.\*

HAY HARVESTED 3 TONS (6,000 lbs.) PER ACRE	Total digestible feed value Equal to { 2000 lbs. linseed meal 2000 lbs. corn & cob meal	STEMS 3,000 lbs.	50% leaves 3,000 lbs.	
	Feed value lost in leaves Equal to { 550 lbs. linseed meal 200 lbs. corn & cob meal	STEMS 3,000 lbs.	40% leaves 2,000 lbs.	leaves lost 1,000 lbs.
	Feed value lost in leaves Equal to { 800 lbs. linseed meal 450 lbs. corn & cob meal	STEMS 3,000 lbs.	30% leaves 1,300 lbs.	leaves lost 1,700 lbs.
	Feed value lost in leaves Equal to { 1250 lbs. linseed meal 350 lbs. corn & cob meal	STEMS 3,000 lbs.	20% leaves 800 lbs.	leaves lost 2,200 lbs.

MILK PRODUCTION PER ACRE OF HAY	MECHANICALLY DRIED WITH HEATED AIR		113%
	MECHANICALLY DRIED WITH UNHEATED AIR		108%
	FIELD-CURED—NO RAIN DAMAGE Set at 100% for basis of comparison		100%
	FIELD-CURED WITH SOME RAIN DAMAGE	80%	

ACRES NEEDED TO PRODUCE EQUIVALENT FEED (U.S.D.A. Data)	FIELD-CURED HAY Requires 25% more acres than mechanically cured hay—for same feed value
	MECHANICALLY CURED HAY Requires less acres for same amount of feed

\*From Crop Dryer Manufacturers Association.



## THE CASE FOR CORN DRYING

Farmers of the United States lose from \$500,000,000 to \$1,000,000,000 every year just because of losses to the corn crop. Losses amount to 10% to 20% of the total crop. To many farmers it means the difference between success and failure.

Let's examine the major reasons for this huge loss:

- *Field losses.* For safe storage, ear corn should not have a moisture content of over 15%. If the corn is left in the field until it is dry enough it is subject to severe losses due to weather. As corn stands in the field, wind and rain break down the stalks, or ears drop off. Often corn is left standing in the field until mid-winter or spring. By that time so much is down that it cannot be harvested efficiently. According to U.S.D.A., corn that is harvested after November 15 suffers losses as high as 20%. Sometimes entire fields of corn are lost just because weather did not permit harvesting after the corn reached a safe moisture content.

Early picking for mechanical drying prevents much loss due to corn borers. The crop is harvested *before* the borer-weakened stalks collapse.

Rain, snow, sun and frost bleach away food value in the corn as it stands in the field. It's a real loss for you who feed corn you raise... more feed supplements must be purchased.



- *Loss to insects.* By waiting until corn is dry before harvesting, the danger of loss to insects is greater. This is because the dry, brittle kernels will crack more easily during harvest and the cracks are an invitation to insects.

- *Spoiling in storage.* If the corn has too high a moisture content when it is stored, it will mold or spoil. An adequate drying system will eliminate this spoilage.

- *Dockage losses at the market.* This is a definite money loss to the farmer who has to sell corn that is above the desirable moisture content. The price drops drastically as the moisture content increases.

## HOW TO PREVENT CORN LOSSES

Much of the corn grower's loss can be eliminated by mechanical drying. Here's how:

*By harvesting corn at proper maturity.* This means that the corn can be picked at 33% moisture content, for corn is fully mature and at its peak yield at that stage. Mechanical drying brings it down to safe moisture content without leaving it in the field, exposed to weather.



By picking corn earlier, the stalks are in good condition... which means that the harvesting equipment will function at top efficiency. There is much less field loss. The corn is picked cleaner; and the new picker-sheller will be most effective if used at this earlier stage rather than later on tough, dry corn.

*Discourage insects* by picking and storing corn in good physical condition. When corn is picked at a fairly high moisture content, it will not be apt to crack. Insects attack cracked and broken corn first.

*Eliminate spoilage and loss of feed value in storage* by drying mechanically. Drying can be done evenly to safe storage levels.

*Prevent dockage at the market* by selling corn with the proper moisture content. See examples on page 25.

*Prevent waste of time, labor and storage space.* Harvest can be planned for when crop is at peak value... With crop drying equipment, you need not depend upon the undependable weather to do your drying. Often, early harvested corn will leave the field clear and ready for winter wheat or a cover crop. The need for storage space can be reduced up to 50% by shelling and drying corn and not storing it on the ear.



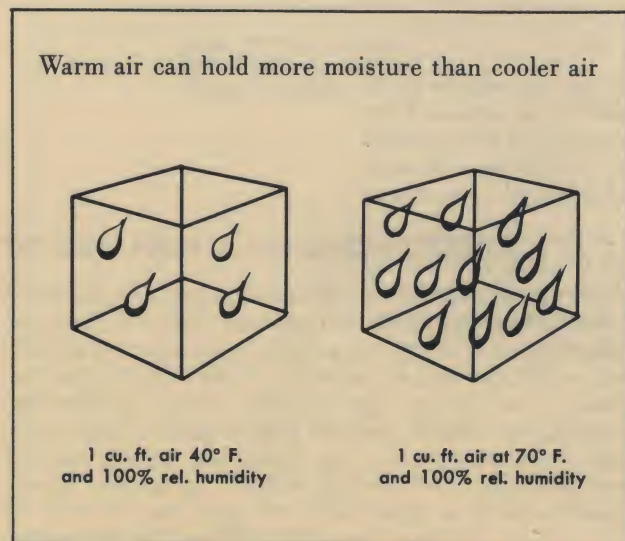
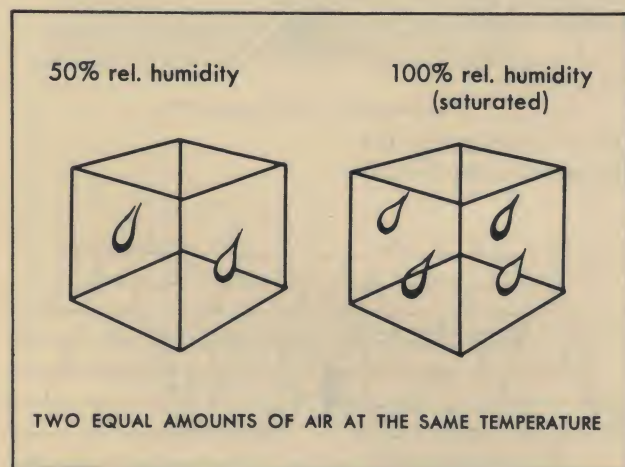
## HOW TO DRY CROPS MECHANICALLY

You have seen, in the preceding pages, the value of mechanical crop drying. In "normal" years as well as the "wet" years, crop drying will add to your profits by helping you reap more and better crops—faster.

This section of the booklet will tell you how to use and apply mechanical drying for greater profits.

The first thing to understand is the idea of *relative humidity*. Relative humidity simply refers to the amount of moisture in the air . . . it does so by comparing the amount of moisture in the air to the total amount of moisture which the air could hold at that temperature. If the relative humidity is 50% it means that the air (without changing temperature) could actually hold twice as much moisture. As relative humidity reaches 100% the air becomes saturated and can hold no more moisture.

As air becomes warmer, its ability to hold moisture increases. For instance, air at 70° can hold almost three times as much moisture as air at 40°.



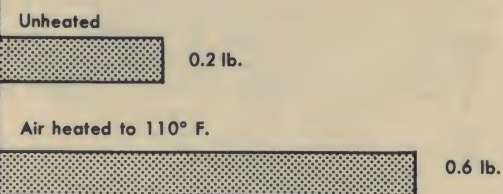
Mechanical crop drying operates on the principal of lowering the relative humidity of the air in and around the crop to be dried.

The addition of heat to the air lowers the air's relative humidity and therefore increases its ability to absorb water from the crop. And even if the air being circulated through the crop is not heated, it replaces air of a higher relative humidity that has already taken some of the moisture from the crop.

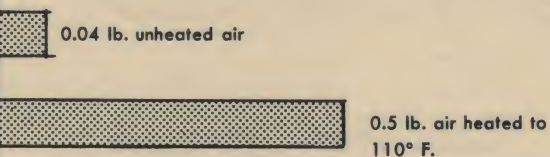
**MECHANICAL DRYING PAYS REGARDLESS OF WEATHER . . .** In addition to a better quality crop, mechanical drying saves time. The effectiveness of heated air drying is shown in this chart.

Water vapor that can be removed per 1000 cubic feet of air\*

Good drying weather—80° F. 50% rel. humidity



Poor drying weather—80° F. 90% rel. humidity



\*U.S.D.A.

As can be seen from the facts presented on this page, the more heat that is added to the drying air, the faster the crop will dry. There is very little danger of the crop becoming over-heated as long as moisture is being evaporated from it. That is because the process of evaporation requires a good deal of heat and serves to cool the crop. Table XX on page 36 tells how to figure relative humidity.



### THREE BASIC METHODS OF MECHANICAL DRYING

There are three fundamental ways of mechanical crop drying:

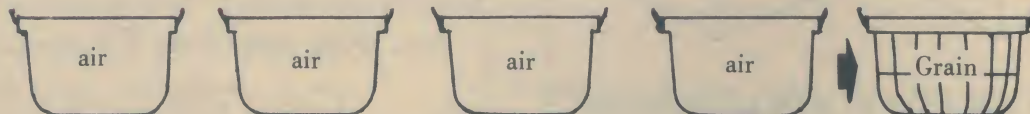
- 1 Get the crop under cover and protect it from the weather. Then force unheated air through it. (Pages 13,17, 20, 23,30,31.)
- 2 Add a moderate amount of heat to the air being forced through the crop. This method uses large air volumes and just enough heat to keep the air's relative humidity at a good drying level. (Page 17,19, and 24-32.)
- 3 Use large amounts of air and large amounts of heat for speedy drying. (Pages 19,25,29) With this method the farmer has the most control over drying, even on very humid days.

High quality Lennox equipment is available for crop drying by any one of the three basic methods. Details of Lennox equipment are described on pages 33-34.

To better describe the various drying methods, the following pages will show how they are applied to crops.

#### NOTE:

When talking of the flow of air in crop drying, the term "cfm" is often used. This means cubic feet of air per minute.



Example: An air flow of 5 cubic feet per minute (cfm) for each bushel of grain is the same as forcing four bushels of air through every bushel of grain each minute. (A cubic foot of air is approximately  $\frac{4}{5}$  of a bushel by volume.)

The above is a typical rate of air flow. Therefore the velocity of the air going through the crop is relatively slow, less than speed at which you walk. Therefore you should not expect to feel strong currents of air coming from the outlet side of the crop.



# HAY DRYING

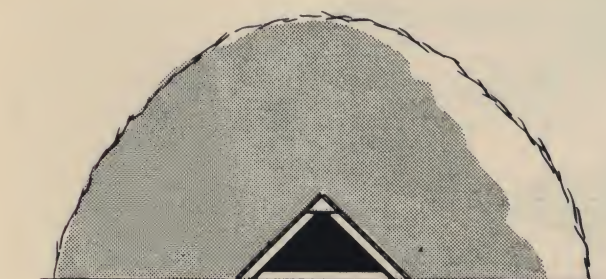
## I. DRYING HAY WITH UNHEATED AIR

Hay drying with unheated air is usually done right in the building in which the hay is to be stored. The following material illustrates typical ways of drying hay with unheated forced air. Every drying situation differs from the next, therefore the methods described here can

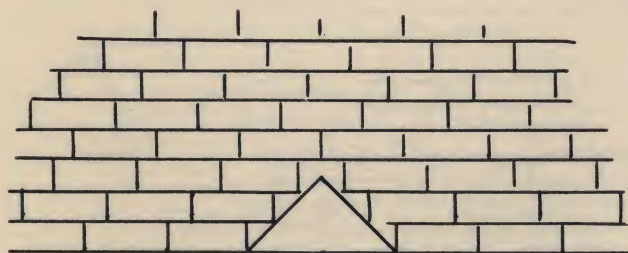
only be suggestions of good drying practice. Table 1 on page 16 provides data such as fan size to use with various hay depths and mow areas. Detailed descriptions of Lennox fans are on page 33.

**FIGURE 1.**

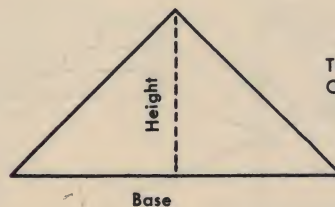
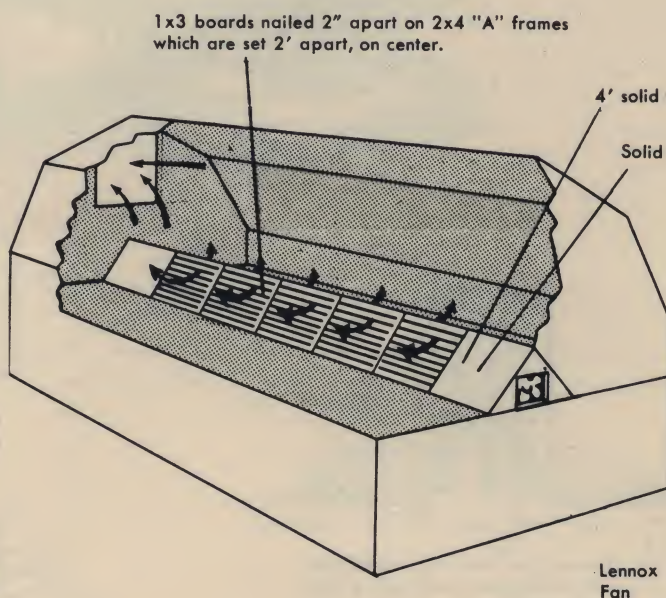
"A" frame system for drying chopped, baled or long hay in mows ranging up to 24' wide. Table I on page 16 indicates the fan to use. It also shows what the cross-sectional area of the main air duct should be.



NOTE: Spread hay evenly over duct.



Suggested bale placement.  
Bales should not weigh over  
70 lbs. wet weight.



TO FIGURE THE AREA  
OF THE TRIANGLE:  
Multiply height times  
base and divide by 2.

## TO DRY FIRST & SECOND CUTTINGS:

If second or third cuttings are to be dried in the same mow with the first cutting, the following can be done: Pile the first cutting at the fan end of the mow and plug the duct about 6' short of where the hay ends. Then dry that cutting. For the next cutting, remove the plug and pile second cutting behind the first. With heavy paper, seal the slatted duct sides up to the point where the second cutting hay begins. If second cutting does not fill mow to end, plug the duct same as before. Third cutting can be handled in the same manner.

NOTE: If desired, the "A" frame duct can taper to  $\frac{1}{2}$  size at the far end.

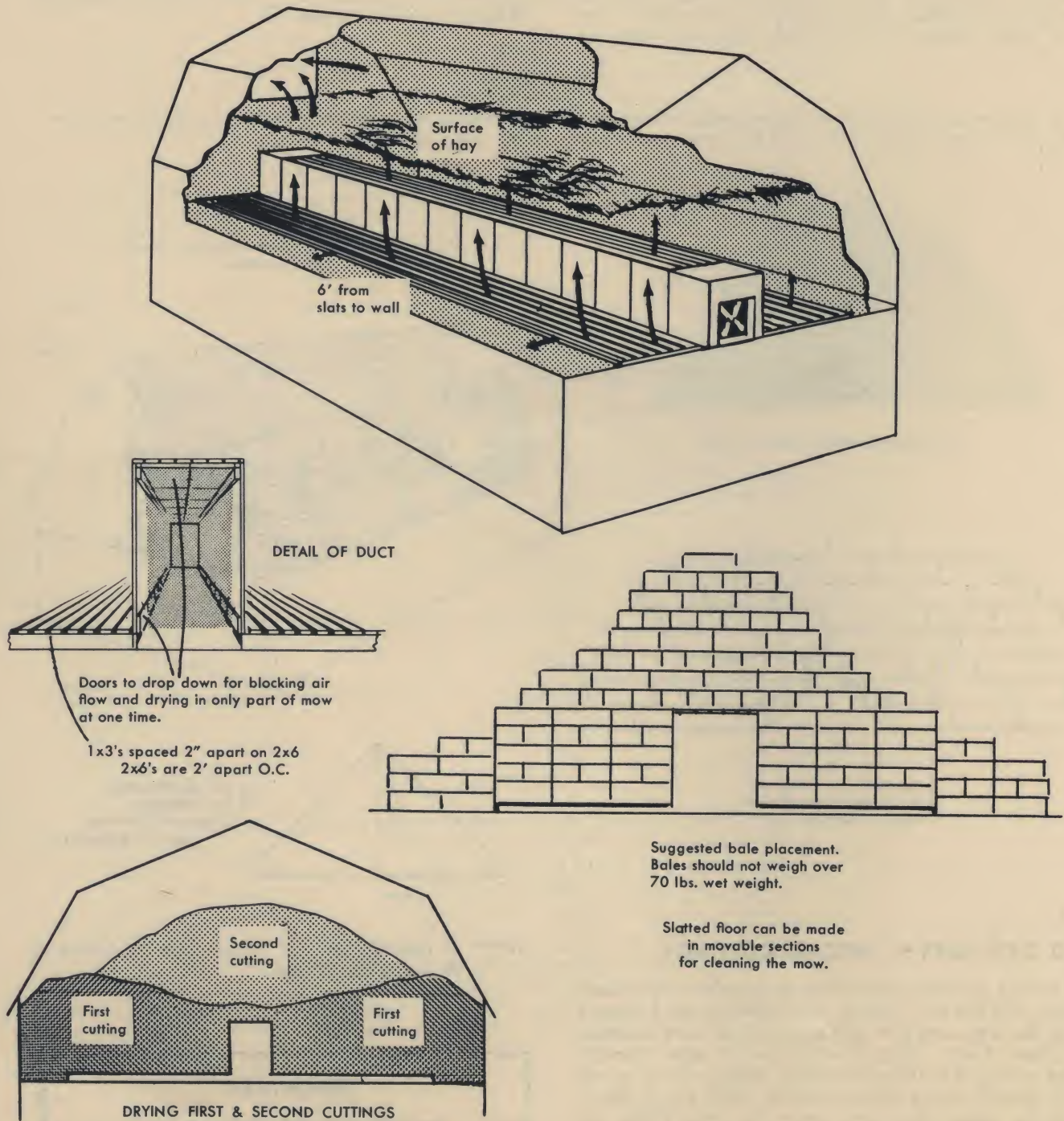
## IMPORTANT

Wet bales should not weigh over  
70 lbs. wet weight.



**FIGURE 2.**

Slatted floor system for curing chopped, baled or long hay. For use in mows 30 to 36 feet wide. See Table I on page 16 for correct duct size, fan size and depth of hay.

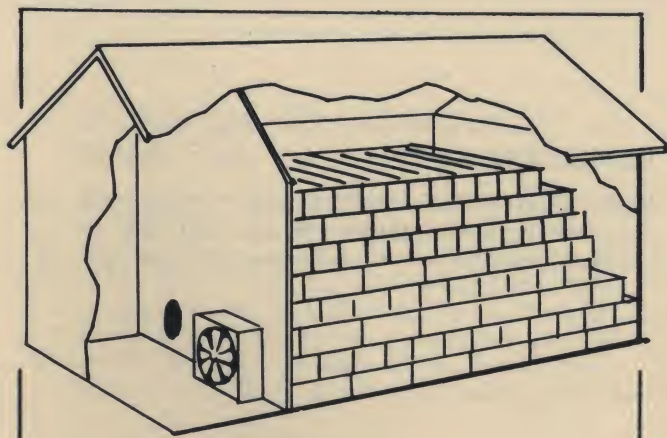
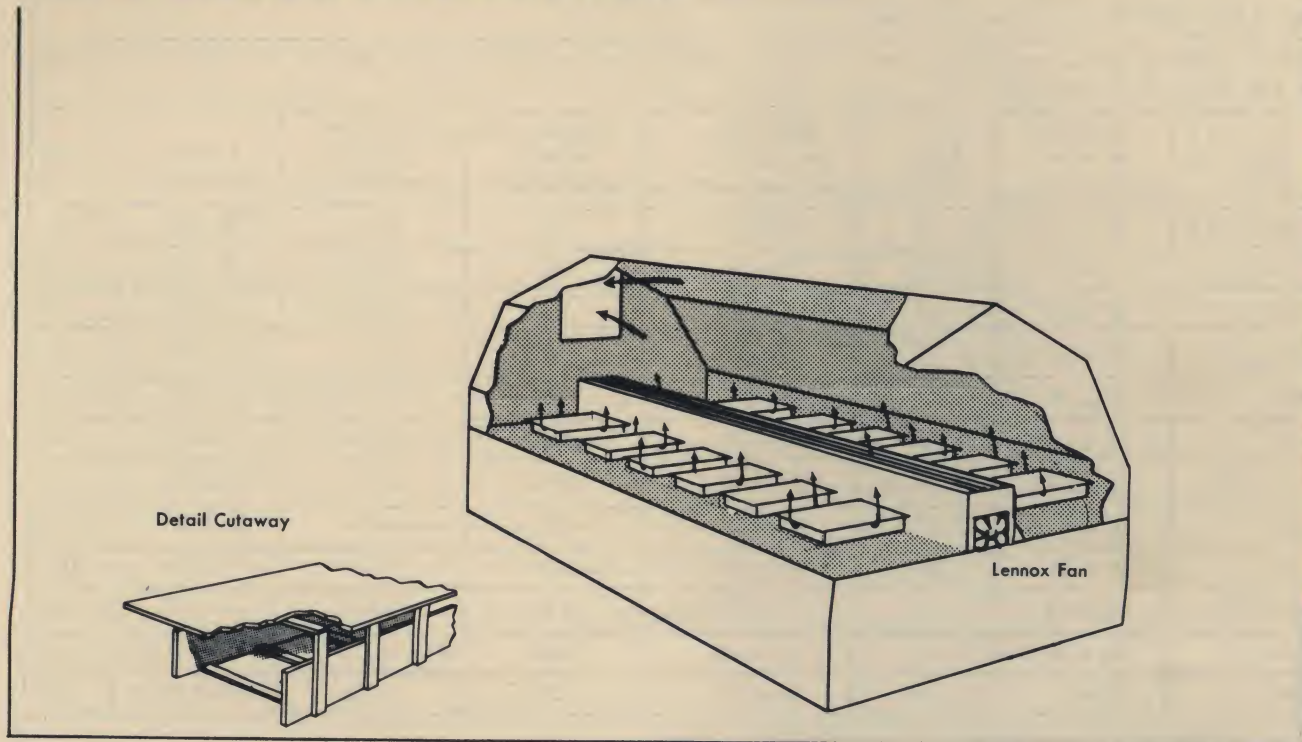


First cutting is dried with top doors of duct closed. Second cutting is dried with top doors open and doors to slatted floor closed.



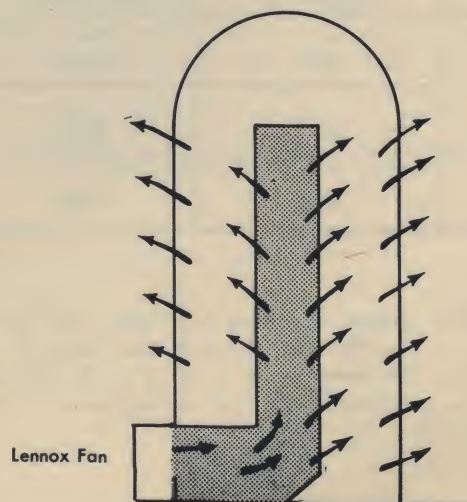
**FIGURE 3.**

This type of mow system can be used for drying LONG OR CHOPPED HAY in mows over 36 feet wide. For area of main duct, fan size and hay depth see Table I on page 16.

**FIGURE 4.**

### **BALES FORM DRYING TUNNEL**

This could be a money-saving method of drying baled hay. A partition near one end of the building has openings so that fan can be moved from one tunnel to another. Tunnels are 3 bales high near fan and only 2 bales high at other end. Cordwood or rough timber supports the bales. Stagger bales.

**FIGURE 5.**

This is a round vertical steel building made especially for drying. Center vertical duct and side-walls are perforated. Best used for chopped hay.



TABLE I

DRYING HAY WITH UNHEATED AIR. INITIAL MOISTURE CONTENT, 35%. Hay is dried to 20% moisture content. This table is figured on the basis of 600 cubic feet of air per minute for each ton of hay. (400 cu. ft. of space per ton.)							
NOTE: A higher initial moisture content of the hay will require more drying time per ton. See Table III on page 17, and Table IV on page 18.							
Floor space	Example of mow dimensions	Depth of hay	Min. cross section area of main duct	Approx. drying time, days		Lennox fan used	Tons
				Normal conditions*	Humid conditions		
1500 sq. ft.	30 x 50	8'	16 sq. ft.	4-8	10-14	42-5 B1	30
834	24 x 35	12'	16 sq. ft.	4-8	10-14	42-5 B1	25
500	20 x 25	16'	16 sq. ft.	4-8	10-14	42-5 B1	20
1600 sq. ft.	40 x 40	8'	16 sq. ft.	4-8	10-14	42-7 B1	32
932	26 x 36	12'	16 sq. ft.	4-8	10-14	42-7 B1	28
625	24 x 26	16'	16 sq. ft.	4-8	10-14	42-7 B1	25
1550 sq. ft.	31 x 50	8'	16 sq. ft.	4-8	10-14	36-5 B1	31
800	20 x 40	12'	16 sq. ft.	4-8	10-14	36-5 B1	24
474	19 x 25	16'	16 sq. ft.	4-8	10-14	36-5 B1	19
1600 sq. ft.	40 x 40	8'	16 sq. ft.	4-8	10-14	36-7 B1	32
900	30 x 30	12'	16 sq. ft.	4-8	10-14	36-7 B1	27
600	20 x 30	16'	16 sq. ft.	4-8	10-14	36-7 B1	24

\*Normal conditions have been assumed at 75° F and 65% relative humidity

TABLE II

	Moisture content at which hay may be brought in.	Maximum moisture content for safe storage.
Chopped hay	40%	20%
Baled hay	35%	20%
Long hay	45%	20%

### IMPORTANT...

BE SURE TO HAVE AIR OUTLETS IN THE MOW SO THAT MOISTURE LADEN AIR CAN ESCAPE. Outlet openings should total 1½ to 2 times the inlet opening.

**CAUTION:** Remember that wet hay will be much heavier than the field-cured hay you might be more used to putting up. So be sure the storage building is strong enough to hold it.

*Do not delay in starting fan immediately after the hay is in the mow.*

It is also good practice to have the fan on the opposite end of the barn from loading area. This reduces the chance of loose hay getting into the fan.

### TESTING FOR DRYNESS

When drying hay in a mow, this simple method will help you determine when the drying process is complete. When the top two feet of hay feels dry enough, turn off the fan for a period of 12 hours. Then turn on the fan and immediately walk over the top of the hay in the mow. If you find any spots where warm air is rising, you will know the hay is not dry enough in those spots. In this case operate the fan for 24 more hours. Repeat the test... if no warm air is felt then turn off the fan and wait 24 hours and test again, just to make sure it is dry.



TABLE III

Changes in condition of hay with various moisture contents, amount required to make one ton of "dry" hay, and the amount of water that must be removed.

Condition of forage or hay	Average moisture content	Amount of forage or partly cured hay needed to make a ton of dry hay	Amount of water to be removed in making a ton of dry hay
	(percent)	(pounds)	(pounds)
Freshly cut . . . . .	75	7,000	5,000
Wilted—very heavy to handle . . . . .	50	3,500	1,500
Still heavy to handle . . . . .	40	2,900	900
<b>Begins to handle like hay . . . . .</b>	<b>35</b>	<b>2,700</b>	<b>700</b>
Leaves still hang on . . . . .	32½	2,600	600
Tough leaves rattle . . . . .	30	2,500	500
Would heat in ordinary storage . . . . .	27½	2,420	420
Slightly tough—leaves shatter off . . . . .	25	2,340	340
Dry enough for ordinary mow storage . . . . .	20	2,190	190
Time to stop the fan . . . . .	15	2,060	60
"Dry" hay . . . . .	12½	2,000	None

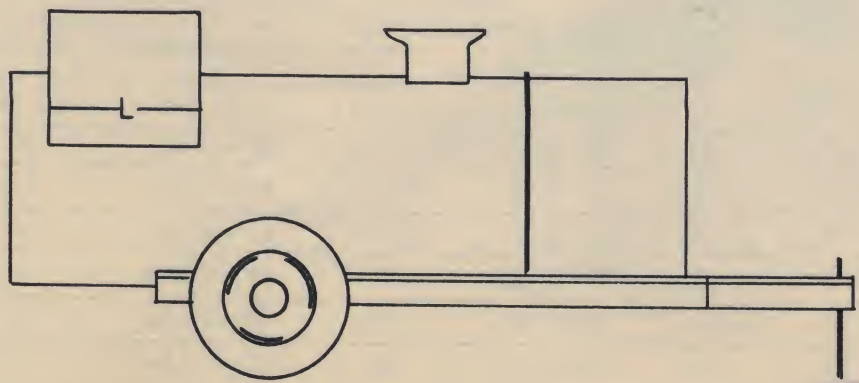
Michigan State College agricultural bulletin 219

## II. DRYING HAY WITH MODERATELY HEATED AIR

Hay drying with moderately heated air is done in much the same manner as drying with unheated air. The main difference is that an oil or gas-fired unit adds some heat to the air. This reduces the relative humidity of the air and drying is faster and more dependable. Thus, drying can continue at a steady pace even during humid days and nights. See Table IV, page 18, for drying times.

Figures 1, 2, 3, 4 and 5 on the preceding pages show

hay drying structures. By replacing the fan with the Lennox Cropmaster, these structures serve very well for heated air hay drying. The Cropmaster is completely mobile and has a long canvas duct for easy connections. It is indirect fired which means that products of combustion are carried away through a flue rather than being blown into the crop. Fire danger is eliminated. The Cropmaster has a welded steel heat exchanger, flue, and a full set of safety controls just the same as famous Lennox oil furnaces for homes. (See page 34 for full details.)



The Lennox Cropmaster.  
Fast, safe, dependable hay  
drying with heated air.



TABLE IV

Time and oil requirements to dry hay with heated air.

Starting Moisture Content	Pounds of water per ton at start	Pounds of water removed in drying 1 ton to 20%	Approx. gallons oil used to dry 1 ton to 20%	Approx. gallons oil used to dry 20 tons to 20%	Approx. time to dry 20 tons while burning 10 gal. per hour
60%	2400	2000	28.6	562	56 hrs.
55%	1958	1558	23.1	460	46 hrs.
50%	1600	1200	18.6	372	37 hrs.
45%	1310	910	14.6	292	29 hrs.
40%	1070	670	11.1	222	22 hrs.
*35%	860	460	7.9	158	16 hrs.
30%	685	285	5.1	102	10 hrs.
25%	535	135	2.5	50	5 hrs.

\*Maximum Moisture For Economical Drying

TABLE V

Drying 35% moisture hay to 20% with the Lennox Cropmaster . . . examples

Floor space	Example of mow dimensions in feet.	Depth of hay in feet	Tons hay	Min. cross section area of main duct	Approx. drying time, hours	Cropmaster used (model)	Approx. Gallons of oil burned per hour
1500 sq. ft.	30 x 50	8	30	16 sq. ft.	20	42"—5 hp	10
834 sq. ft.	24 x 35	12	25	16 sq. ft.	18	42"—5 hp	10
500 sq. ft.	20 x 25	16	20	16 sq. ft.	16	42"—5 hp	10
1600 sq. ft.	40 x 40	8	32	16 sq. ft.	21	42"—7½ hp	10
932 sq. ft.	26 x 36	12	28	16 sq. ft.	19	42"—7½ hp	10
625 sq. ft.	24 x 26	16	25	16 sq. ft.	18	42"—7½ hp	10

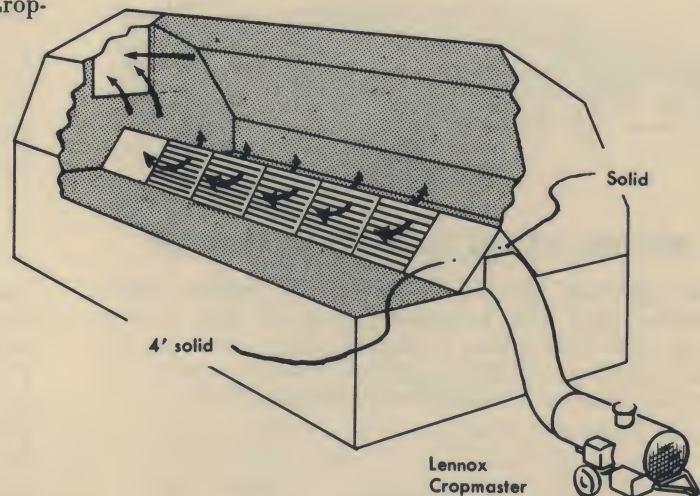


FIGURE 6.

This is a typical mow hay drying application of the Lennox Cropmaster. The set-up is the same as drying with unheated air (see page 13). In place of the stationary fan there is a canvas duct leading to the Cropmaster.

NOTE: As long as plenty of air is passing through the crop and water is being evaporated, there is no danger of excessive temperature rise. In fact, cool air is often felt coming from the crop even though warm air is being blown in. This cooling is due to the evaporation of water from the crop.

1x3 boards nailed 2" apart on 2x4 "A" frames which are set 2' apart, on center.



The degree to which the air passing through the Cropmaster is heated is determined by the amount of air passing through and the amount of oil being burned. Table XIX on page 35 of the Appendix shows this data.

**BE SURE TO HAVE AIR OUTLETS IN THE MOW SO THAT MOISTURE LADEN AIR CAN ESCAPE.** Outlet openings should total  $1\frac{1}{2}$  to 2 times the inlet opening.

When drying hay in a mow, this simple method will help you determine when the drying process is complete. When the top two feet of hay feels dry enough, turn off the dryer for a period of 12 hours. Then turn on the fan only and immediately walk over the top of the hay in the mow. If you find any spots where warm

air is rising, you will know the hay is not dry enough in those spots. In this case operate the dryer for 24 more hours. Repeat the test . . . if no warm air is felt then turn off the dryer and wait 24 hours and test again, just to make sure it is dry.

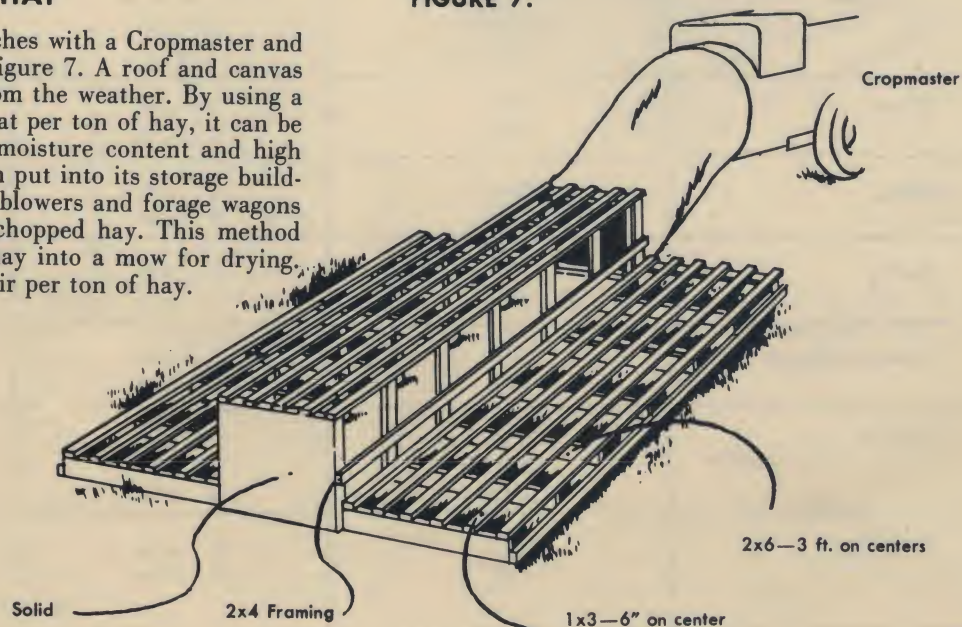
NOTE: When drying any crop, the fan should be left running for one hour after shutting off the burner. Table III on page 17 shows the condition of hay at various moisture contents.

### III BATCH DRYING HAY

Hay can be dried in batches with a Cropmaster and structure as shown in Figure 7. A roof and canvas sides protect the hay from the weather. By using a lot of air and a lot of heat per ton of hay, it can be dried quickly to a safe moisture content and high nutrient value. It is then put into its storage building. The use of modern blowers and forage wagons eliminates leaf loss on chopped hay. This method eliminates putting wet hay into a mow for drying.

Use at least 600 cfm air per ton of hay.

FIGURE 7.





## GRAIN DRYING

The three basic methods of crop drying apply to grain as well as they do to hay. In this area, too, there is Lennox equipment designed to help the farmer realize a greater profit on his time and investment. We will apply the three basic methods to grain drying, one by one.

### I. DRYING GRAIN WITH UNHEATED AIR

The following material illustrates how various grains can be dried with unheated forced air. This section deals with such grains as shelled corn, wheat, barley, oats, soybeans and grain sorghum. For best results, the outdoor relative humidity should be below 70%.

#### Moisture and air limitations

When drying grain with unheated air, certain minimum rates of air flow through the grain must be maintained.

#### Testing for moisture content

For accurate checks of moisture content when drying small grain, you can use any one of several commercial moisture testers which are on the market. Also, most grain buying establishments are equipped to test grain samples for moisture content.

There is also a maximum moisture content at which the various grains can be put in the bin for drying . . . and there are certain moisture levels for safe storage. Table VI below lists those limitations. From the minimum air flow requirements listed in Table VI, you will be able to determine the proper fan capacity to use. (Example: To dry 2200 bushels of shelled corn from 25% moisture content, down to 13% moisture content. The table shows that 5 cfm of air is required per bushel. 5 x 2200 equals a total necessary cfm of 11,000.)

**TABLE VI. Max. Moisture Limits and Air Flow Requirements, Unheated Air.**

Grain	Max. moisture content at which to start drying	Minimum air flow in cfm per bushel	Safe storage moisture content
Wheat	20% 18%	3 cfm 2 cfm	13%
Oats	25% 20%	3 cfm 2 cfm	13%
Barley	20% 18%	3 cfm 2 cfm	12%
Grain sorghum	20% 18%	3 cfm 2¼ cfm	12%
Shelled corn	25% 22½% 20%	5 cfm 4 cfm 3 cfm	13%
Soybeans	20% 18%	3 cfm 2 cfm	11%



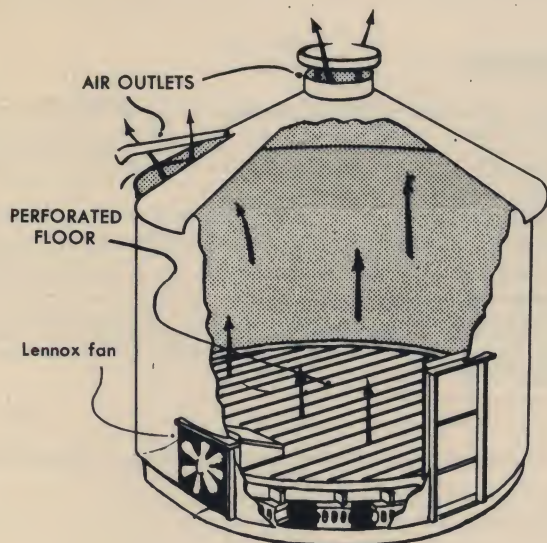


FIGURE 8.

Figure 8 illustrates a single grain bin adapted to grain or shelled corn drying with unheated air. The fan used with this system should be able to deliver 1,000 cubic feet of air per minute for each 20 square feet of floor space. Example: 200 sq. ft. of bin floor requires 10,000 cfm from the fan.

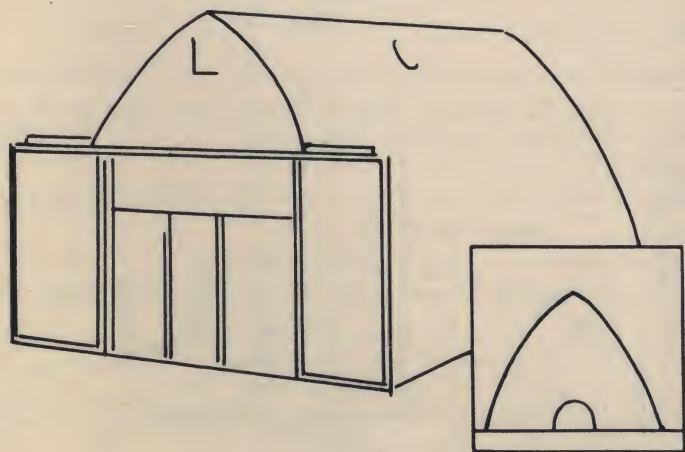


FIGURE 10.

Figure 10 shows another type of metal bin which is often used for grain drying. A perforated metal duct runs down the center of the bin.

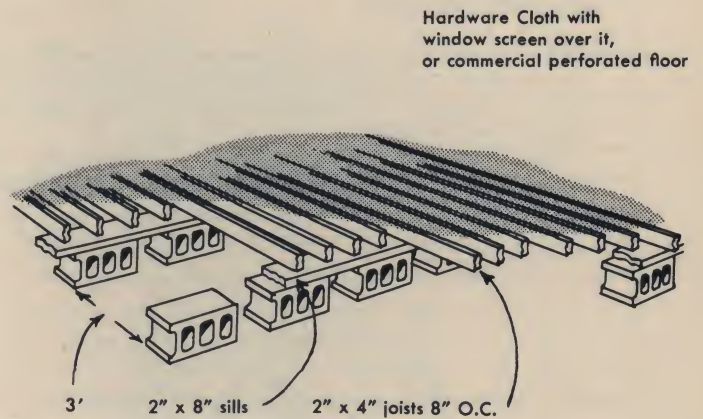
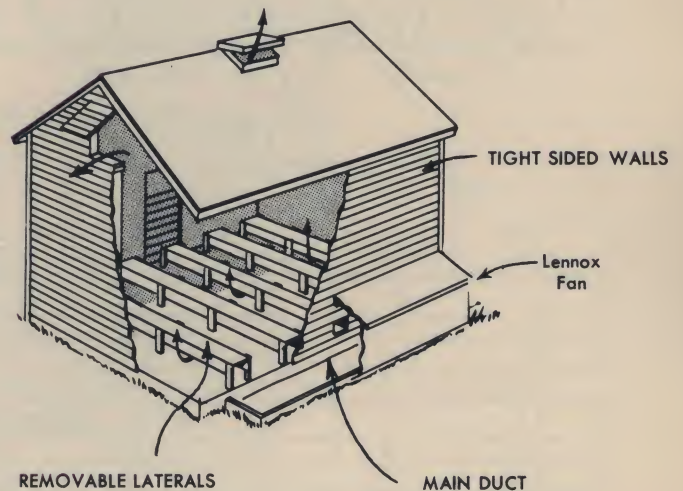


FIGURE 9.

Figure 9 illustrates how a false floor for forced air drying can be added to an existing grain bin.

**IMPORTANT:** A minimum of 35% of the floor area must be "free area" open for air passage.



Wooden bin with lateral ducts 12" wide, 12" high, with 6" opening at the bottom of each duct side.

FIGURE 11.

Figure 11 shows a wooden grain bin equipped to dry grain and shelled corn. The bin has tight sides with ample air outlets at the top. The lateral ducts should be built in about 6-foot sections so that they can be removed as the bin is emptied.



## BEFORE DRYING

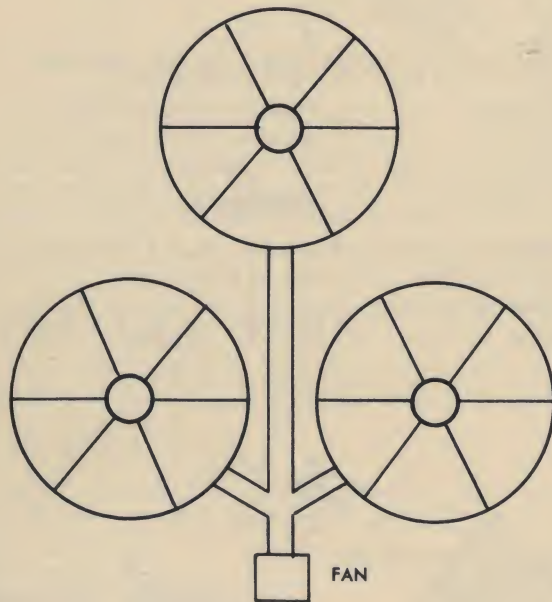
Clean and spray the bins, inside and out. Also spray the area around the bins before filling them with grain. This will do much to prevent the grain from becoming infested with insects.

Check the bin for tight floor and walls. Be sure ventilators are open. Be sure air distribution system is installed properly.

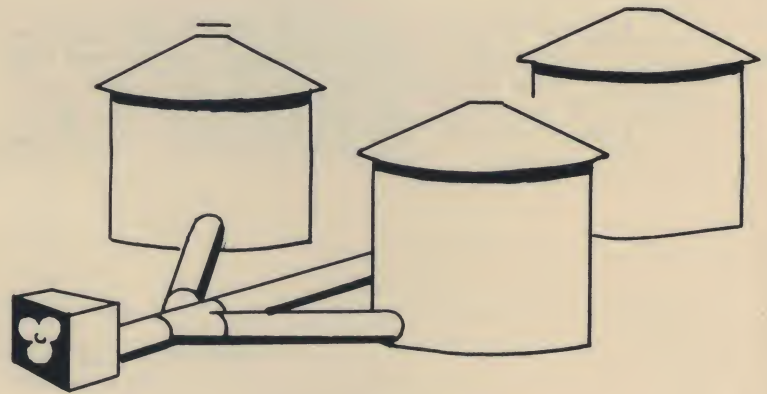
## DRYING

As soon as the ventilating duct is covered with grain, the fan should be started. Do not fill bin above eaves. Level the grain off so that top surface is flat; this helps assure uniform air flow.

Be sure grain is as clean as possible. Leaves, weeds and trash channel air passage and cause uneven drying. If the grain is distributed evenly as the bin is being filled, cracked grain and foreign matter will not accumulate in pockets and cause trouble. Do not fill bins with grain that has a moisture content more than that shown in Table VI on page 20.



TOP VIEW



SIDE VIEW

NOTE: All bins must be filled to the same depth and with the same kind of grain.

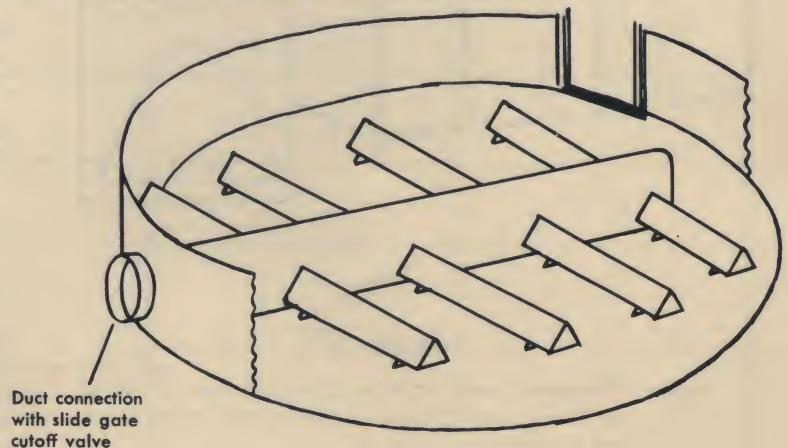
FIGURE 12.

FLOOR DUCT SYSTEM

## MULTIPLE BIN GRAIN DRYING

In grain drying, the number of bins can vary from one to several, depending upon the fan and the grain's air requirements. Tables VII and VIII on page 23 show the number of bins and depth of grain that can be used with standard Lennox 21" fans for grain drying.

This system is also well-suited to heated air drying. (Page 24.)





**TABLE VII. GRAIN DRYING CAPACITY—Lennox 21" 3 H.P. Fan**  
Max. Recommended Grain Depth, Ft.

Grain	Max. Moisture %	CFM Bu.	14 Ft. Diam. Bins			18 Ft. Diam. Bins		
			Depth Ft. 1 Bin	Depth Ft. 2 Bins	Depth Ft. 3 Bins	Depth Ft. 1 Bin	Depth Ft. 2 Bins	Depth Ft. 3 Bins
Shelled Corn	25	5	7.4	5.6	4.2	6.2	3.9	2.8
	20	3	10.7	8.6	6.7	9.3	6.2	4.5
	18	2	14.6	11.8	9.6	12.7	9.0	6.6
	16	1	Full to eaves	Full to eaves	16.8	21.6	16.0	12.4
Wheat	20	3	7.4	6.5	5.6	6.8	5.3	4.1
	18	2	9.7	8.7	7.6	9.0	7.2	5.8
	16	1	14.6	13.0	12.2	13.9	12.1	10.2
Oats	25	3	8.7	7.3	6.1	7.9	5.7	4.3
	20	2	11.3	10.0	8.5	10.5	8.0	6.2
	18	1½	14.0	12.1	10.5	12.9	10.1	8.0
	16	1	Full to eaves	15.4	14.1	16.7	13.7	11.2
Rice	22	2½	9.4	8.3	6.9	8.7	6.6	5.0
	20	2	10.8	9.7	8.3	10.1	7.9	6.1
	18	1½	12.8	11.8	10.3	12.3	9.9	7.8
	16	1	16.7	15.5	13.8	15.9	13.5	11.0
Soybeans	20	3	11.9	9.1	6.9	10.0	6.4	4.6
	18	2	Full to eaves	12.6	10.0	13.8	9.4	6.7
	16	1	Full to eaves	Full to eaves	17.9	25.0	17.1	12.8
Grain Sorghum	20	3	8.0	6.9	5.8	7.4	5.5	4.2
	18	2¼	9.5	8.5	7.3	8.9	6.9	5.4
	16	1½	12.4	11.2	9.9	11.6	9.5	7.6
Barley	20	3	8.9	7.5	6.2	8.1	5.8	4.3
	18	2	11.6	10.3	8.7	10.9	8.2	6.3
	16	1	17.5	16.3	14.5	16.8	14.2	11.4

**TABLE VIII. GRAIN DRYING CAPACITY—Lennox 21" 5 H.P. Fan**  
Max. Recommended Grain Depth, Ft.

Grain	Max. Moisture %	CFM Bu.	14 Ft. Diam. Bins			18 Ft. Diam. Bins		
			Depth Ft. 1 Bin	Depth Ft. 2 Bins	Depth Ft. 3 Bins	Depth Ft. 1 Bin	Depth Ft. 2 Bins	Depth Ft. 3 Bins
Shelled Corn	25	5	8.5	6.2	4.6	7.0	4.2	2.9
	20	3	12.4	9.7	7.3	10.6	6.8	4.8
	18	2	Full to eaves	13.5	10.5	14.5	9.8	7.1
	16	1	Full to eaves	Full to eaves	Full to eaves	Full to eaves	18.0	13.5
Wheat	20	3	8.5	7.5	6.3	7.9	6.0	4.5
	18	2	11.1	10.1	8.7	10.4	8.3	6.4
	16	1	17.4	14.5	14.0	16.0	13.9	11.5
Oats	25	3	10.0	8.4	6.8	9.0	6.3	4.6
	20	2	13.3	11.4	9.5	12.0	9.0	6.7
	18	1½	Full to eaves	13.7	11.9	14.7	11.5	8.8
	16	1	Full to eaves	Full to eaves	16.0	Full to eaves	15.7	12.4
Rice	22	2½	11.0	9.4	7.8	10.0	7.4	5.4
	20	2	12.5	11.0	9.4	11.5	8.9	6.7
	18	1½	14.6	13.4	11.8	14.1	11.3	8.6
	16	1	Full to eaves	Full to eaves	15.8	18.7	15.5	12.3
Soybeans	20	3	13.5	10.1	7.5	11.3	6.9	4.8
	18	2	Full to eaves	14.2	10.9	15.8	10.1	7.1
	16	1	Full to eaves	Full to eaves	20.1	Full to eaves	18.9	13.8
Grain Sorghum	20	3	9.4	8.0	6.5	8.4	6.2	4.5
	18	2¼	11.1	9.7	8.2	10.3	7.8	5.9
	16	1½	Full to eaves	13.0	11.4	13.5	10.9	8.4
Barley	20	3	10.4	8.5	6.8	9.3	6.4	4.6
	18	2	13.8	11.7	9.8	12.5	9.2	6.8
	16	1	Full to eaves	18.7	16.6	18.7	16.2	12.6



## II. DRYING GRAIN WITH MODERATELY HEATED AIR

The methods used for drying grain with moderately heated air are much the same as for drying with unheated air, as described in the preceding pages. The chief difference is that some heat is added to the air to lower its relative humidity. This results in drying regardless of weather conditions.

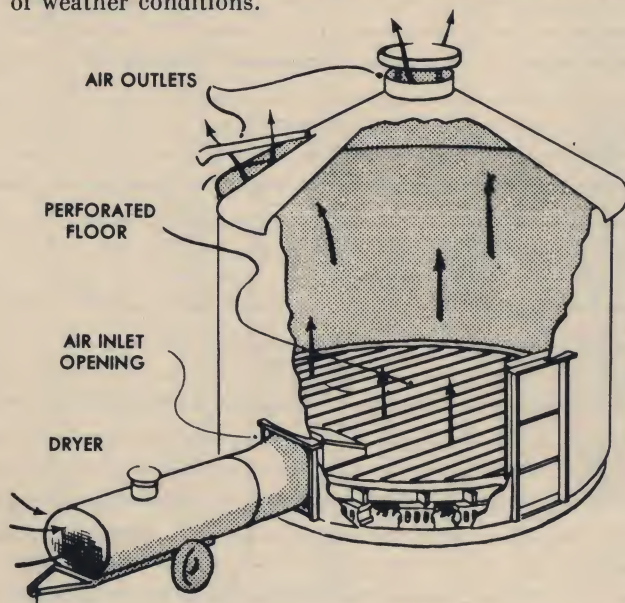


FIGURE 13.

Grain drying with heated air, using the Lennox Cropmaster.

Drying grain with moderately heated air can be done with the Lennox fans that are used for unheated air drying, but with a LPG (bottled gas) heat unit added. Or it can be done very satisfactorily with the Lennox oil-fired Cropmaster. The structures used for grain drying with moderately heated air are the same as those shown in Figures 8, 9, 10, 11 and 12.

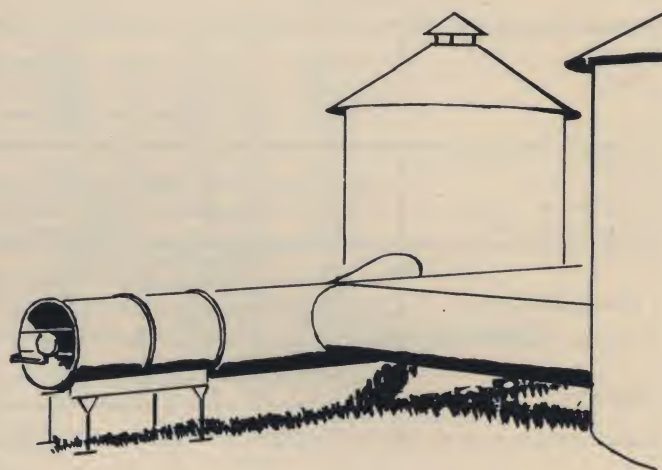


FIGURE 14.

Lennox fan and LPG heat unit set up for grain drying.

TABLE IX. Heated Air Grain Drying Requirements

GRAIN	Safe maximum temperature of drying air	Maximum moisture content at which to start drying	Minimum air flow-cfm/bushel	Safe storage moisture content
Seed Corn	110° F	25%	5	13%
Wheat	140° F	20%	3	13%
Oats	120° F	25%	3	13%
Rice	120° F	22%	3	13%
Popcorn	90° F	25%	5	12%
Soybeans	140° F	20%	3	11%
Barley	140° F	20%	3	12%
Grain Sorghum	140° F	20%	3	12%
Shelled Corn	140° F	25%	5	13%
Ear Corn	140° F	30%	5	13%



## PROFIT BY GRAIN DRYING

Besides the saving due to early harvest and extremely low field losses, and besides preventing spoilage, mechan-

ical crop drying brings greater profits by assuring top prices at the market.

Table X shows the extra market profit due to drying corn down to 15.5% moisture content before selling.

TABLE X

% moisture content	Price of corn- \$ per bu.	Discount due to moisture- cents per bu.	Shrink loss due to drying- lbs. per bu.	Shrink loss due to drying- cents per bu.	Profit due to drying corn to 15.5% moisture
16	1.28½	1½	0.3	0.69	0.81 ¢ per bu.
20	1.13½	16½	2.5	5.81	10.69 ¢ per bu.
25	.93½	36½	5.3	12.31	24.19 ¢ per bu.
30	.73½	56½	8.1	18.63	37.18 ¢ per bu.
35	.53½	76½	10.9	25.07	51.43 ¢ per bu.

This table is based on cash grain market for 15.5% moisture corn at \$1.30 per bushel. Typical moisture discounts used are 3¢ per bushel up to 17%; 4¢ per bushel over 17%.

## III. BATCH DRYING OF GRAIN

A fast and efficient method of drying grain is by using the third basic method of crop drying . . . batch drying with large amounts of heat and air.

For this method, wagon box drying and batch bin drying is very satisfactory. Crops can be dried quickly for marketing at premium prices—or conditioned for safe storage until a favorable selling time.

### Wagon box grain drying

A very flexible and mobile way to dry grain is in wagon boxes equipped with a perforated floor set a few inches above the regular tight floor. The grain is put into the wagon box directly from the harvesting machine. Then the wagon is attached to a warm air duct from the dryer.

At least two wagons should be attached to the dryer at the same time for efficient operation. The Lennox Cropmaster can easily handle three wagons at one time. A Lennox fan and LPG heating unit also work well for this type of operation.

After the grain is dry, it should be cooled before it is stored away in a bin. The most efficient way to cool it is to have a separate fan system to which the wagons are connected. Otherwise the Cropmaster's burner would

have to shut off and unheated air forced through the grain. But with a separate fan for cooling, the Cropmaster can continue drying other wagons.

For a drying operation of this type, refer to Figures 15 and 16. Sufficient wagons are needed so that harvest-

ing operations can go smoothly and so that the full capacity of the drying and cooling system is being used.



FIGURE 15.

Barge-type wagon fitted for drying. Lennox perforated floors are available in several standard sizes.

In case of rain, a tarpaulin over the wagon will keep the rain off the grain. Sides of tarpaulin should be loose so air can escape.

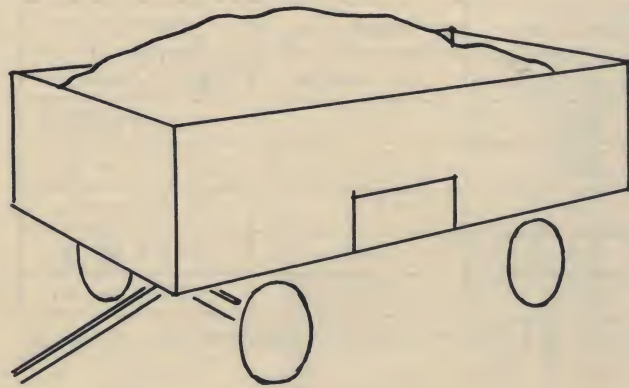


FIGURE 16.

Multiple wagon grain drying and cooling with a Lennox Cropmaster and Lennox fan. See Table XI for data.

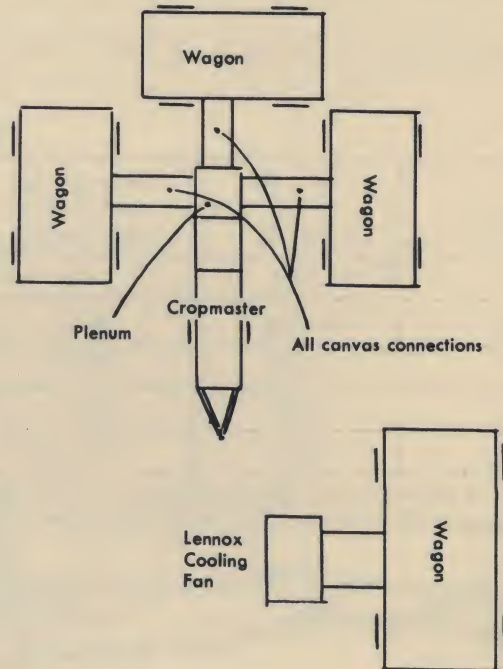


TABLE XI. Wagon Drying of Grain with Lennox Cropmaster and LPG Units

Type of Grain	Starting Moisture Content %	Safe Storage Moisture Content %	Pounds of Water Per Bu. to Remove in Drying to Safe Moisture Content	Approx. Gals. of Oil Req. to Dry 300 Bu. or 3 Wagons	Approx. Time Req. to Dry 3 Wagons at 10 gal/hr.	Approx. Time Req. to Dry 2 Wagons at 5 gal/hr.	Approx. Gals. of Propane Used to Dry 300 Bu. or 3 Wagons	Approx. Time Req. to Dry 2 Wagons at 625,000 Btuh. on 21" Fan	Approx. Time Req. to Dry 3 Wagons at 1,000,000 Btuh. on 36" Fan
Shelled Corn	30	13%	13.1	58	6 hrs.	8 hrs.	77	7½ hrs.	7 hrs.
	25		8.8	42	4½ hrs.	6 hrs.	54	5½ hrs.	5 hrs.
	20		4.7	25	2½ hrs.	3½ hrs.	32	3½ hrs.	3 hrs.
Wheat	20	13%	5.2	28	3 hrs.	4 hrs.	36	3½ hrs.	3½ hrs.
	18		3.7	21	2½ hrs.	3 hrs.	26	2½ hrs.	2½ hrs.
	16		2.1	12	1½ hrs.	2 hrs.	15	1½ hrs.	1½ hrs.
Oats	20	13%	2.7	15	2 hrs.	2 hrs.	19	2 hrs.	2 hrs.
	18		1.9	11	1½ hrs.	1½ hrs.	14	1½ hrs.	1½ hrs.
	16		1.1	7	1 hrs.	1 hr.	8	1 hr.	1 hr.
Soybeans	20	11%	6.6	36	4 hrs.	5 hrs.	46	4½ hrs.	4½ hrs.
	17		4.2	24	2½ hrs.	3½ hrs.	31	3 hrs.	3 hrs.
	14		2.1	13	1½ hrs.	2 hrs.	16	2 hrs.	1½ hrs.
Grain Sorghums	20	12%	5.3	29	3 hrs.	4 hrs.	37	4 hrs.	3½ hrs.
	18		3.9	22	2½ hrs.	3 hrs.	28	3 hrs.	3 hrs.
	16		2.5	14	1½ hrs.	2 hrs.	19	2 hrs.	2 hrs.



### Batch bin drying of grain

Drying with the Lennox batch bin is a fast, efficient way to bring grain down to a safe moisture content. Lennox batch bins are available in 300 or 600 bushel capacities. The 600 bushel bin can dry as fast as the best corn picker-sheller can harvest. Normally, the grain is dry in 3 hours, cooled in one hour and unloaded in another hour. It takes about an hour to load a 600 bushel batch bin. Heat to the bin is supplied by a Cropmaster burning  $10\frac{1}{2}$

gallons of oil per hour or with an LPG heat unit of 2 million Btuh capacity. On rainy days, a tarpaulin can be stretched over the bin . . . be sure there is sufficient space for escaping air.

Figures 17, 18, 19, 20, show Lennox batch bin drying operations. Tables on page 28, 29 list batch bin drying data.

**FIGURE 17.**

600 bu. batch bin with Cropmaster



**FIGURE 18.**

600 bu. batch bin with LPG unit and fan  
Wheels and hitch for easy moving.



**FIGURE 19.**

Two 300 bu. bins are joined to make 600 bu. bin.



**FIGURE 20.**

Spreader auger.





FIGURE 21.

Convenient augers and hopper make an easy job of loading, unloading and recirculating the grain.

**NOTE:** Corn drying with a Lennox batch bin should not be compared with kiln drying. With the Lennox method, the corn's temperature never exceeds a safe limit of 140°F, but with kiln drying the corn's temperature usually runs considerably higher. Spoils corn for feed value and milling.

TABLE XII. Shelled Corn

47.32# Dry Matter per Bushel

Starting Moisture Content %	Pounds H <sub>2</sub> O per Bushel	Pounds H <sub>2</sub> O Removed in Lowering Moisture to 13%	Approx. Bushels Dried per Gal. Oil to 13%	Approx. Gal. Req. to Dry 600 Bu. to 13%	Approx. Time Req. to Dry 600 Bu. at 10 Gal./Hr.	Approx. Bu. Dried per Gal. Propane Direct Fired	Approx. Gal. of Propane to Dry 600 Bu. to 13%	Approx. Time Required to Dry 300 Bu. to 13% (625,000 Btuh, 21" Fan)	Approx. Time Required to Dry 300 Bu. to 13% (1,000,000 Btuh, 36" Fan)	Approx. Time Required to Dry 600 Bu. to 13% (2,000,000 Btuh, 42" Fan)
35	25.6	18.5	3.8	158	16 hrs.	2.9	207	15½ hrs.	9½ hrs.	9½ hrs.
30	20.2	13.1	5.2	115	12 hrs.	3.9	154	11½ hrs.	7½ hrs.	7½ hrs.
28	18.4	11.3	5.8	104	11 hrs.	4.4	136	10 hrs.	6½ hrs.	6½ hrs.
26	16.6	9.5	6.6	91	9½ hrs.	5.1	118	9 hrs.	5½ hrs.	5½ hrs.
24	14.9	7.8	7.8	77	8 hrs.	6.0	100	7½ hrs.	5 hrs.	5 hrs.
22	13.3	6.2	9.4	64	6½ hrs.	7.3	82	6 hrs.	4 hrs.	4 hrs.
20	11.8	4.7	12.0	50	5 hrs.	9.4	64	5 hrs.	3 hrs.	3 hrs.
18	10.4	3.3	16.6	36	4 hrs.	12.9	47	3½ hrs.	2½ hrs.	2½ hrs.
16	9.0	1.9	27.8	22	2½ hrs.	21.0	29	2½ hrs.	1½ hrs.	1½ hrs.
14	7.7	0.6	85.0	7	1 hr.	68.0	9	1 hr.	½ hr.	½ hr.

TABLE XIII Wheat

51.6# Dry Matter per Bushel

Starting Moisture Content %	Pounds H <sub>2</sub> O per Bushel	Pounds H <sub>2</sub> O Removed in Lowering Moisture to 13%	Approx. Bushels Dried per Gal. Oil to 13%	Approx. Gal. Req. to Dry 600 Bu. to 13%	Approx. Time Req. to Dry 600 Bu. at 10 Gal./Hr.	Approx. Bu. Dried per Gal. Propane Direct Fired	Approx. Gal. of Propane to Dry 600 Bu. to 13%	Approx. Time Required to Dry 300 Bu. to 13% (625,000 Btuh, 21" Fan)	Approx. Time Required to Dry 300 Bu. to 13% (1,000,000 Btuh, 36" Fan)	Approx. Time Required to Dry 600 Bu. to 13% (2,000,000 Btuh, 42" Fan)
35	27.8	20.1	3.5	172	17½ hrs.	2.7	232	17 hrs.	11 hrs.	11 hrs.
30	22.1	14.4	4.6	131	13½ hrs.	3.6	167	12½ hrs.	8 hrs.	8 hrs.
28	20.1	12.4	5.3	113	12 hrs.	4.0	150	11 hrs.	7 hrs.	7 hrs.
26	18.2	10.5	6.0	100	10 hrs.	4.6	130	9½ hrs.	6 hrs.	6 hrs.
24	16.4	8.7	7.0	86	9 hrs.	5.3	113	8½ hrs.	5½ hrs.	5½ hrs.
22	14.6	6.9	8.5	71	7½ hrs.	6.4	94	7 hrs.	4½ hrs.	4½ hrs.
20	12.9	5.2	10.9	55	6 hrs.	8.4	72	5½ hrs.	3½ hrs.	3½ hrs.
18	11.4	3.7	14.7	41	4½ hrs.	11.3	53	4 hrs.	2½ hrs.	2½ hrs.
16	9.8	2.1	25.0	24	3 hrs.	19.8	30	2½ hrs.	1½ hrs.	1½ hrs.
14	8.4	0.7	74.0	8	1 hr.	57.0	11	1 hr.	1 hr.	1 hr.

1 Bu. = 60 lbs. wheat at 14% moisture.



TABLE XIV. Oats

## 27.4# Dry Matter per Bushel

Starting Moisture Content %	Pounds H <sub>2</sub> O per Bushel	Pounds H <sub>2</sub> O Removed in Lowering Moisture to 13%	Approx. Bushels Dried per Gal. Oil to 13%	Approx. Gal. Req. to Dry 600 Bu. to 13%	Approx. Time Req. to Dry 600 Bu. at 10 Gal./Hr.	Approx. Bu. Dried per Gal. Propane Direct Fired	Approx. Gal. of Propane to Dry 600 Bu. to 13%	Approx. Time Required to Dry 300 Bu. to 13% (625,000 Btuh, 21" Fan)	Approx. Time Required to Dry 300 Bu. to 13% (1,000,000 Btuh, 36" Fan)	Approx. Time Required to Dry 600 Bu. to 13% (2,000,000 Btuh, 42" Fan)
35	14.6	10.5	6.7	90	9 hrs.	5.1	118	9 hrs.	5½ hrs.	5½ hrs.
30	11.7	7.6	8.8	68	7 hrs.	6.7	90	7 hrs.	4½ hrs.	4½ hrs.
28	10.6	6.5	10.0	60	6 hrs.	7.6	79	6 hrs.	4 hrs.	4 hrs.
26	9.6	5.5	11.4	53	5½ hrs.	8.7	69	5½ hrs.	3½ hrs.	3½ hrs.
24	8.6	4.5	13.5	45	4½ hrs.	10.3	58	4½ hrs.	3 hrs.	3 hrs.
22	7.7	3.6	16.3	37	4 hrs.	12.3	49	4 hrs.	2½ hrs.	2½ hrs.
20	6.8	2.7	21.0	29	3 hrs.	16.0	38	3 hrs.	2 hrs.	2 hrs.
18	6.0	1.9	28.8	21	2½ hrs.	22.0	27	2 hrs.	1½ hrs.	1½ hrs.
16	5.2	1.1	48.2	13	1½ hrs.	36.7	16	1½ hrs.	1 hr.	1 hr.
14	4.5	0.4	128.0	5	1 hr.	98.0	6	½ hr.	½ hr.	½ hr.

1 Bu. = 32 lbs. oats at 14.5% moisture.

TABLE XV. Grain Sorghum

## 47.32# Dry Matter per Bushel or 56# at 15.5% Moisture

Starting Moisture Content %	Pounds H <sub>2</sub> O per Bushel	Pounds H <sub>2</sub> O Removed in Lowering Moisture to 12%	Approx. Bushels Dried per Gal. Oil to 12%	Approx. Gal. Req. to Dry 600 Bu. to 12%	Approx. Time Req. to Dry 600 Bu. at 10 Gal./Hr.	Approx. Bu. Dried per Gal. Propane Direct Fired	Approx. Gal. of Propane to Dry 600 Bu. to 12%	Approx. Time Required to Dry 300 Bu. to 12% (625,000 Btuh, 21" Fan)	Approx. Time Required to Dry 300 Bu. to 12% (1,000,000 Btuh, 36" Fan)	Approx. Time Required to Dry 600 Bu. to 12% (2,000,000 Btuh, 42" Fan)
35	25.4	18.9	3.7	162	16½ hrs.	2.8	214	16 hrs.	10 hrs.	10 hrs.
30	20.2	13.7	4.9	122	12½ hrs.	3.8	158	12 hrs.	7½ hrs.	7½ hrs.
28	18.4	11.9	5.5	109	11 hrs.	4.2	143	10½ hrs.	6½ hrs.	6½ hrs.
26	16.6	10.1	6.2	97	10 hrs.	4.7	128	9½ hrs.	6 hrs.	6 hrs.
24	14.9	8.4	7.1	85	9 hrs.	5.5	109	8 hrs.	5 hrs.	5 hrs.
22	13.3	6.8	8.6	70	7 hrs.	6.6	91	7 hrs.	4½ hrs.	4½ hrs.
20	11.8	5.3	10.6	57	6 hrs.	8.2	73	5½ hrs.	3½ hrs.	3½ hrs.
18	10.4	3.9	14.1	43	4½ hrs.	10.7	56	4½ hrs.	2½ hrs.	2½ hrs.
16	9.0	2.5	21.2	28	3 hrs.	16.3	37	3 hrs.	2 hrs.	2 hrs.
14	7.7	1.2	43.0	14	1½ hrs.	33.0	18	1½ hrs.	1 hr.	1 hr.

TABLE XVI. Soybeans

## 51.6# Dry Matter per Bushel or 60# at 14% Moisture

Starting Moisture Content %	Pounds H <sub>2</sub> O per Bushel	Pounds H <sub>2</sub> O Removed in Lowering Moisture to 11%	Approx. Bushels Dried per Gal. Oil to 11%	Approx. Gal. Req. to Dry 600 Bu. to 11%	Approx. Time Req. to Dry 600 Bu. at 10 Gal./Hr.	Approx. Bu. Dried per Gal. Propane Direct Fired	Approx. Gal. of Propane to Dry 600 Bu. to 11%	Approx. Time Required to Dry 300 Bu. to 11% (625,000 Btuh, 21" Fan)	Approx. Time Required to Dry 300 Bu. to 11% (1,000,000 Btuh, 36" Fan)	Approx. Time Required to Dry 600 Bu. to 11% (2,000,000 Btuh, 42" Fan)
35	27.8	21.2	3.3	182	18½ hrs.	2.5	240	18 hrs.	11 hrs.	11 hrs.
30	22.1	15.8	4.3	140	14 hrs.	3.3	182	13½ hrs.	8½ hrs.	8½ hrs.
28	20.1	13.8	4.7	128	13 hrs.	3.6	167	12½ hrs.	8 hrs.	8 hrs.
26	18.2	11.9	5.3	113	11½ hrs.	4.0	150	11 hrs.	7 hrs.	7 hrs.
24	16.4	10.1	6.0	100	10 hrs.	4.6	130	9½ hrs.	6 hrs.	6 hrs.
22	14.6	8.3	7.0	86	9 hrs.	5.3	113	8½ hrs.	5½ hrs.	5½ hrs.
20	12.9	6.6	8.5	71	7½ hrs.	6.5	92	7 hrs.	4½ hrs.	4½ hrs.
18	11.4	5.1	10.7	56	6 hrs.	8.2	73	5½ hrs.	3½ hrs.	3½ hrs.
16	9.8	3.5	15.2	40	4 hrs.	11.6	52	4 hrs.	2½ hrs.	2½ hrs.
14	8.4	2.1	24.6	25	2½ hrs.	18.7	32	2½ hrs.	1½ hrs.	1½ hrs.
12	7.0	0.8	62.0	10	1 hr.	48.0	13	1 hr.	1 hr.	1 hr.



## DRYING EAR CORN

### I. DRYING EAR CORN WITH UNHEATED AIR

Ear corn with a moisture content as high as 35% can be dried with forced unheated air. Under good weather conditions, it can be dried down to 18% or less average

If the weather following harvest is humid and kernel moisture content remains above 30%, there is some risk of spoilage. However, operation of the fan will keep the grain cool. On rainy or foggy days, the fan should only

be run for 2 or 3 hours—just enough to keep the corn cool without adding any extra moisture to it.

See Table XXIII on page 37.

Figures 22 through 26 show various ways to dry corn with unheated air.

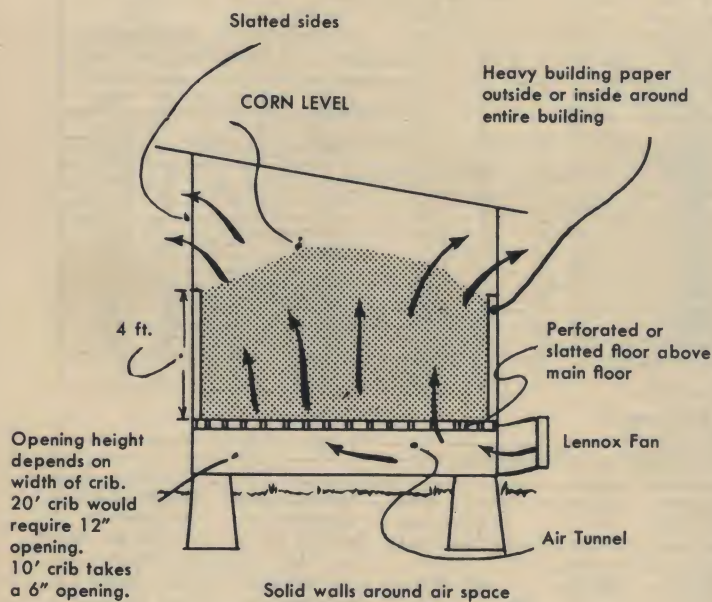


FIGURE 22.

Ear corn drying in a simple crib.

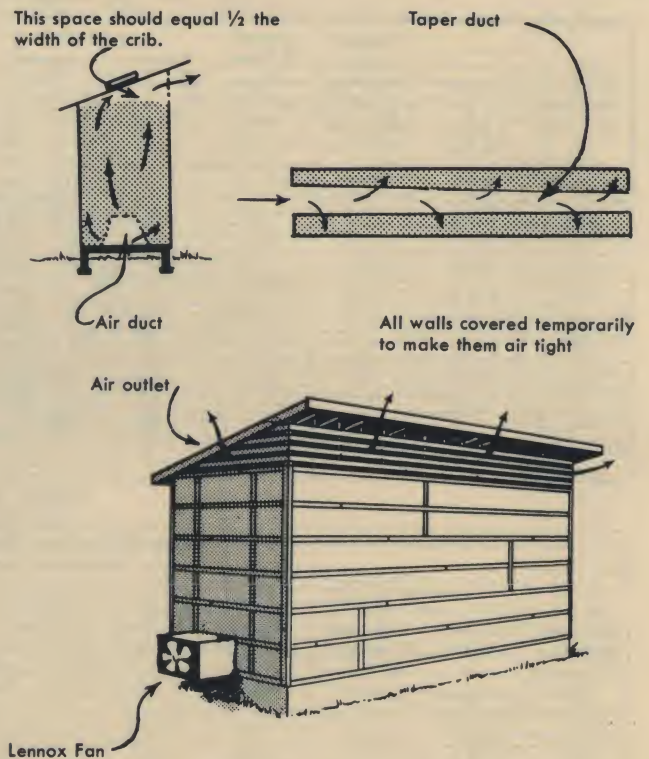


FIGURE 23.

Air duct on inside of single crib. The crib is enclosed with canvas or reinforced paper. Cross section area of duct at fan should equal one square foot per 1,000 cfm of air from the fan.



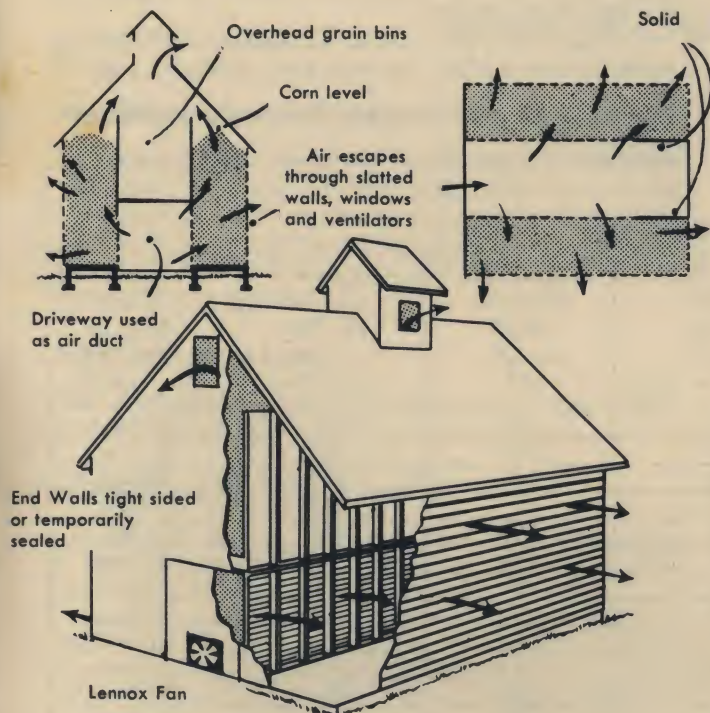
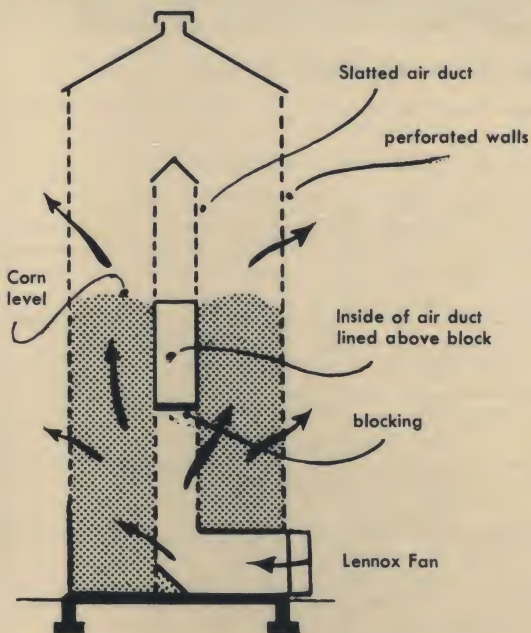


FIGURE 24.

A large double crib adapted to ear corn drying.



Round steel crib with vertical air tunnel up the middle. Such structures are available and they dry up to 4,000 bu. of ear corn at one time.

Note plug that can be moved up air tunnel as more corn is added for drying.

FIGURE 25.

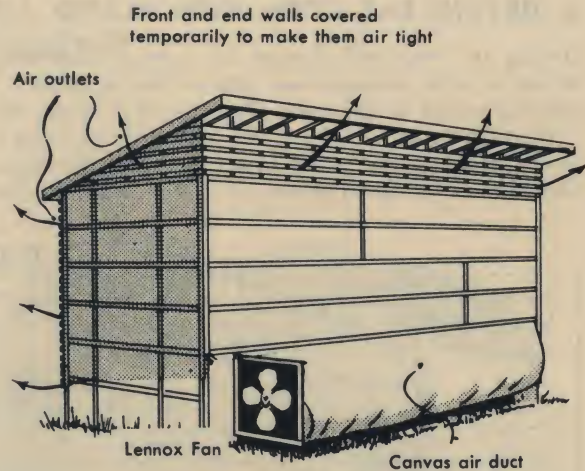


FIGURE 26.

Single crib adapted to forced air drying with outside canvas duct. Cross section of duct area should equal 1 sq. ft. per 1,000 cfm of air from the fan.

### IMPORTANT . . .

The cleaner the corn is, the less resistance there will be to air flow. Lots of husks, silk and foreign matter in the corn blocks air passage and causes slow and uneven drying and greater power consumption.

For best drying, the fan should deliver 5 to 10 cfm of air for each bushel of ear corn to be dried in the crib. (i.e. A 1,000 bushel crib should have a 5,000 to 10,000 cfm fan.)

TABLE XVII. Shrinkage in Ear Corn as Moisture is Removed

Initial moisture content in kernel	Gallons of water to remove per 1000 bu. to reach 18% moisture content	Storage space in cubic feet per bushel
30%	1983	3.13
28%	1608	3.04
26%	1273	2.93
24%	938	2.84
22%	625	2.76
20%	313	2.69
18%	0	2.63

*Check for dryness.* When drying ear corn or shelled corn, most farmers know when the proper moisture content is reached by examining the grain. Some have their own instruments for measuring moisture content. In any case, most grain elevators and mills have accurate equipment for measuring moisture content; all the farmer has to do is bring in a sample.

In the drying of corn or grain, the grain at the bottom of the structure near the dryer loses more moisture than the grain at the top.



## II. DRYING EAR CORN WITH HEATED AIR

Drying ear corn with heated air is much the same as drying it with unheated air (see preceding pages). The structures can be the same (Figures 22 through 26).

Heating the air gives you the advantage of being able to dry day and night in any kind of weather. The Lennox Cropmaster (oil-fired) is ideal for this work. It can be

applied to any of the structures shown in Figures 22 through 26.

Complete descriptions of the Cropmaster, LPG heating units and Lennox fans can be found starting on page 33.

### Amount of moisture to be removed—shrinkage.

See Table XVII on page 31 and Table XXII on page 37.

TABLE XVIII. Ear Corn

Starting Moisture Content of Kernel	Pounds H <sub>2</sub> O in Kernels per Bu.	Pounds H <sub>2</sub> O in Cobs per Bu.	Pounds H <sub>2</sub> O Removed per Bu. to Lower Moisture to 13%	Approx. Bushels Dried per Gal. Oil	Approx. Gal. of Oil Req. to Dry 1000 Bu.	Approx. Time Req. to Dry 1000 Bu. 5 gal/hr.
30	20.3	9.9	22.0	3.09	324	65 hrs.
29	19.3	9.3	20.4	3.26	307	61 hrs.
28	18.4	8.7	18.9	3.46	289	58 hrs.
27	17.5	8.2	17.5	3.67	273	55 hrs.
26	16.5	7.7	16.1	3.90	256	51 hrs.
25	15.7	7.2	14.7	4.21	238	48 hrs.
24	14.9	6.6	13.3	4.56	215	43 hrs.
23	14.1	6.1	12.0	4.97	201	40 hrs.
22	13.3	5.6	10.7	5.48	182	37 hrs.
21	12.5	5.1	9.4	6.14	163	33 hrs.
20	11.8	4.5	8.1	7.00	143	29 hrs.
19	11.1	3.9	6.8	8.20	122	25 hrs.
18	10.4	3.3	5.5	10.00	100	20 hrs.
17	9.7	2.7	4.2	12.85	78	16 hrs.
16	9.0	2.2	3.0	17.75	56	11 hrs.
15	8.3	1.8	1.9	28.20	36	7 hrs.
14	7.6	1.5	0.9	58.00	18	4 hrs.

1 Bu. = 56 Lbs. shelled corn at 15.5% Moisture or 47.32 Lbs. dry matter per bu.



## LENNOX EQUIPMENT

### A WORD OF ASSURANCE

You can depend upon any product you buy that bears the name "Lennox." All this high-quality crop drying equipment is made by the same company that makes the world's most popular line of warm air heating equipment. The same skill and engineering know-how go into Lennox farm equipment.

### Service everywhere

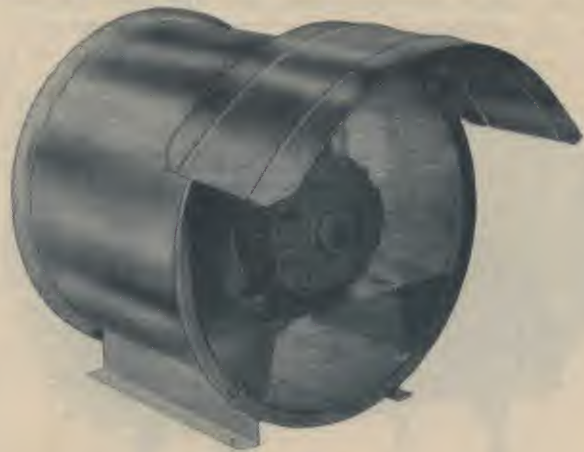
The vast Lennox organization has more than 5,000 dealers. You are never far from expert Lennox service.

### LENNOX AIR POWER FANS

Lennox provides a complete line of crop drying fans from which to choose. Each fan has pre-stressed steel blades which eliminate blade flutter.

A heavy steel wire safety guard is interchangeable to either front or back of the fan. And the fan can be operated in any position for air movement up, down, horizontal or at any angle. They can be connected to a canvas duct or to a solid duct.

The 42" fan is the same as used on the Cropmaster. So if you have a Lennox 42" fan and want to add heated air drying at a later date, all you need to get is the Cropmaster without the fan. And these 42" fans sell for approximately the same price as ordinary 36" fans.



Lennox 36" fan.



42" fan. This same fan section is used on the Lennox Cropmaster.

Lennox Air Power Fans	
21"—4 blade—3 hp—3450 rpm	cfm range: 1,850-8,020
21"—7 blade—5 hp—3450 rpm	cfm range: 3,400-8,500
36"—5 blade—5 hp—1750 rpm	cfm range: 5,200-20,400
36"—7 blade—7½ hp—1750 rpm	cfm range: 8,800-20,200
42"—5 blade—5 hp—1750 rpm	cfm range: 5,000-19,000
42"—7 blade—7½ hp—1750 rpm	cfm range: 5,100-20,000
42"—7 blade—10 hp—1750 rpm	cfm range: 8,100-23,700
42"—7 blade—15 hp—1750 rpm	cfm range: 8,500-26,500



## LENNOX LPG HEATING UNITS

Lennox LPG units for adding heat to a crop drying system range from 50,000 to 2 million btuh. They are the ideal units for adding heat economically to a grain drying operation, using a Lennox fan.

These units are direct-fired, and therefore Lennox does not recommend them for drying hay or ear corn.



The Lennox LPG heating units are constructed of heavy, welded steel. They are the product of the same fine engineering and craftsmanship that go into all Lennox products.

## THE LENNOX CROPMASTER

The Lennox Cropmaster is an extremely versatile piece of crop drying equipment. It's rugged and dependable for years of economical service. Here are some of the outstanding features of the Cropmaster:

Completely mobile for easy moving.  
(Available without the trailer assembly, if desired.)

Indirect-fired. All products of combustion are carried off through a flue—none are blown into the crop.

Wide range of heat output. Heat can be increased or decreased merely by turning a valve. Clean burning Lennox oil burner.

Equipped with a full set of the latest safety controls.

Available with 5 or 7½ hp electric motors—or with gasoline engine to drive fan and to generate electricity for oil burner.

Powerful 42" fan. Comes as a removable section. Fan can be purchased separately and used alone. The rest of the unit can be obtained later, if desired.

Carefully designed and constructed for top efficiency and long life.

## LENNOX BATCH BIN

The new Lennox batch bin is the answer to safe, fast drying of grain and shelled corn. It is ideal for use with a Lennox Cropmaster or a Lennox LPG heat unit and fan. (See page 27.)

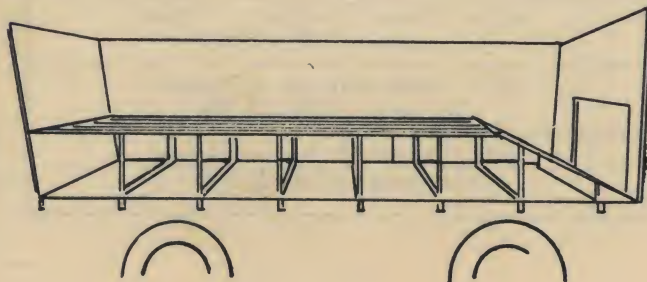
It comes in 300 bushel units. Two such units can be combined to make a 600 bushel batch bin. Standard equipment is an unloading auger and canvas divider. Optional equipment includes brackets for cat-walk; ladder; legs; vertical auger; motor for vertical auger; spreader or leveling chute; wheels and axle set (no tires); hitch assembly; unloading hopper; power take-off for unloading hopper.



The Lennox batch bin. Built for years and years of trouble-free service.

## LENNOX WAGON BOX FLOORS

Here is just the floor to use in wagons when using them for crop drying. They are designed for convenient side air intake. Strong and sturdy of heavy steel; allows generous air flow through the grain. Made to fit barge-type wagon boxes in following sizes: 5' x 10'; 6' x 12'; 6' x 14'; 7' x 12'; 7' x 14'.





# APPENDIX

For you who are interested in the technical aspects of drying, the following data is printed.

## TABLE XIX

This table shows how many degrees the temperature of air will be raised as it passes through a crop dryer. Horizontal lines indicate the heat input. Diagonal lines indicate the amount of air in cubic feet per minute.

Example: 1,000,000 Btuh heat input and 10,000 cfm through the dryer results in a temperature rise of 92.6° F.

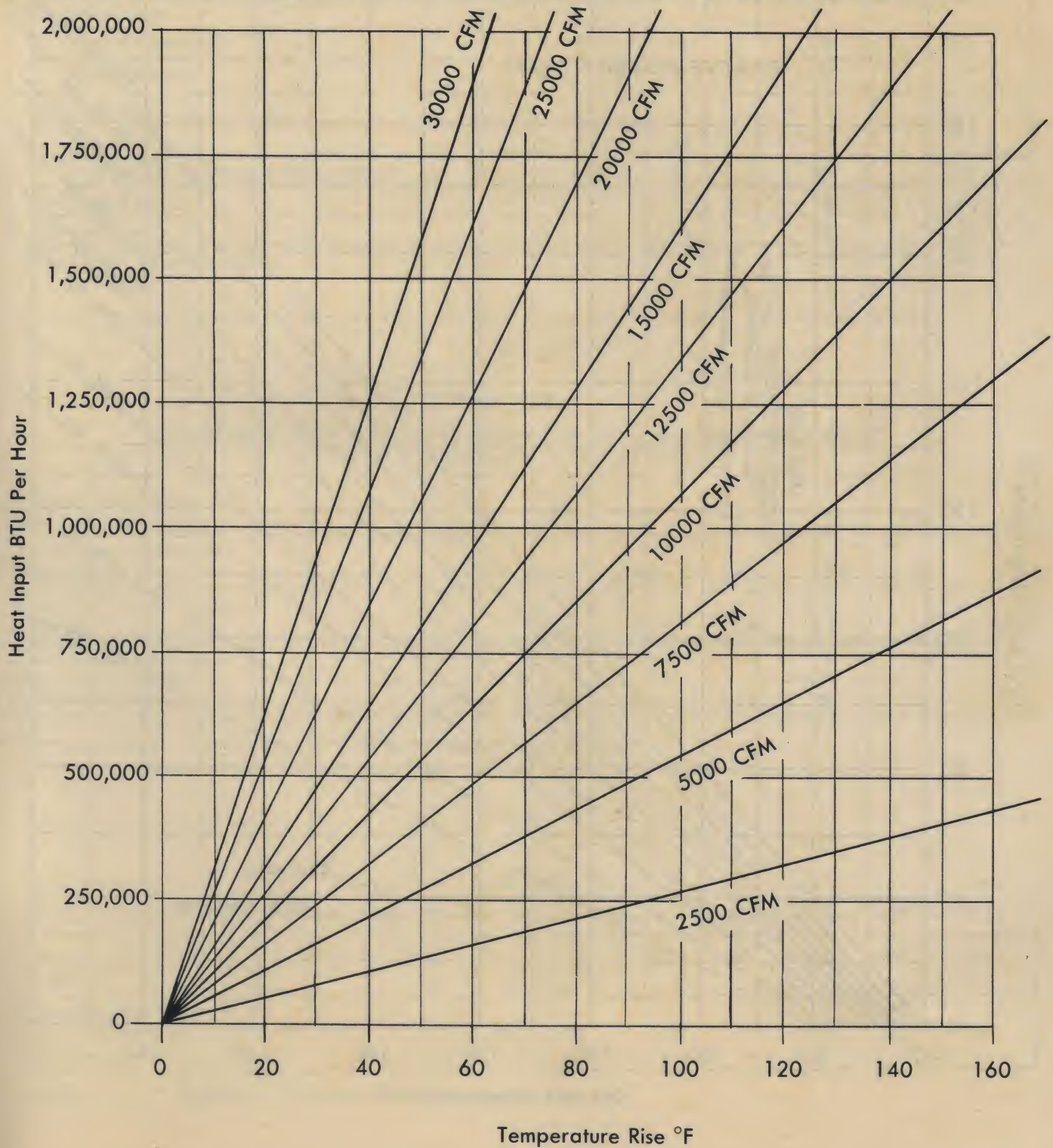
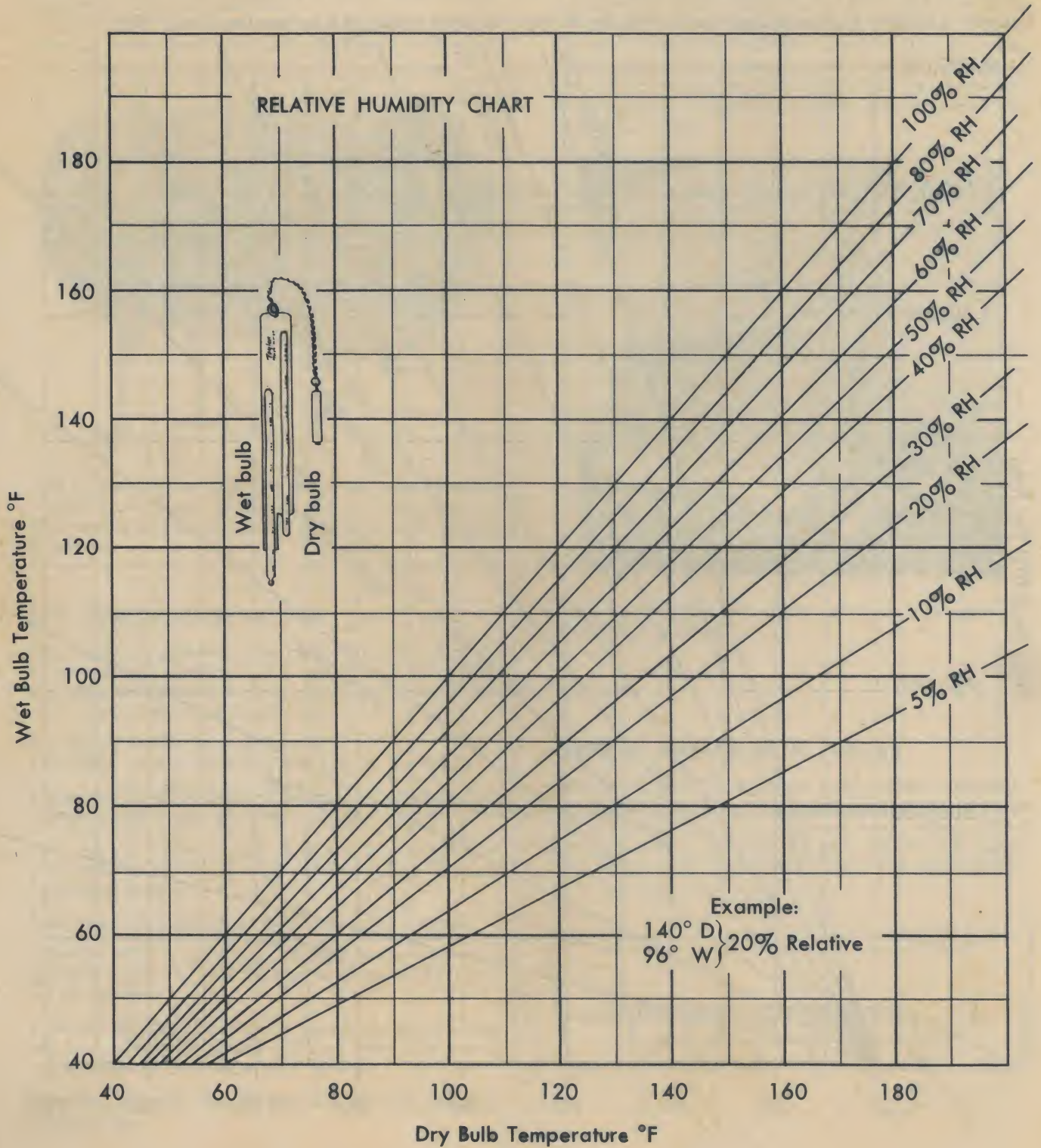




TABLE XX

## RELATIVE HUMIDITY CHART . . . FOR USE WITH A SLING PSYCHROMETER

Example: 140° Dry bulb temp. and 96° wet bulb temp. equals a relative humidity of 20%





**TABLE XXI**

Feed nutrients preserved in harvesting alfalfa by 4 different methods after 6 months of storage

Method of Harvesting	Number of harvests	Dry Matter	Protein	Carotene
		Percent	Percent	Percent
Field-cured hay:				
Not rain damaged	3	76	69	2.7
Rain damaged	2	63	55	.6
Hay dried by forced ventilation:				
Unheated air	3	83	79	7.8
<u>AIR WITH SUPPLEMENTAL HEAT</u>	5	86	80	11.8
Dehydrated hay	4	90	79	23.6
Wilted silage	5	83	83	20.3

USDA Farmers Bulletin No. 2028

**TABLE XXII**

Approximate Pounds of Water to Evaporate from Ear Corn to Obtain One Bushel of Shelled Corn Containing 12 per cent Moisture

Per Cent moisture in kernel on ear	12	15	17½	20	25	30	35	40
Pounds water to remove from kernels	0	2.0	4.0	6.0	10.2	15.0	21	27.5
Pounds of water to remove from cob	0	.5	1.0	3.0	7.3	11.	14	16.5
Total pounds water to evaporate to obtain 1 bushel 12% corn	0	2.5	5.0	9.0	17.5	26.	35	44.

"Seed Corn Drying"—Department of Agricultural Engineering, Ohio State University

**TABLE XXIII**

Relation of Relative Humidity of Air to Lowest Possible Moisture of Corn Kernel (Temperature range 60° to 82° F)

Relative humidity per cent	20	30	40	50	60	70	80	90	100
Lowest possible moisture content of corn—per cent	8	9	10	11	12½	14	17½	22	28

"Seed Corn Drying"—Department of Agricultural Engineering, Ohio State University



## HERE'S WHAT SOME LEADING FARMERS SAY ABOUT THE LENNOX CROPMASTER

The Lennox Furnace Company

Gentlemen:

I thought you would like to know how we feel about our Lennox crop dryer. We cured ninety tons of hay and more than thirty-five hundred bushels of corn. We have never made a wiser investment.

Our milch cows are in very fine condition due to the extra value of our hay. In regard to our corn, we had a moisture content of 28% and in 36 hours it was down to 15%. At a neighboring farm the moisture in the corn was so high that when they shelled some, they found it frozen in the crib. The cobs were soggy. This will mean quite a lot of spoiled corn this spring.

It cost us about \$2.40 a ton for hay and less than 3¢ a bushel to dry the corn, which we consider is not an expense, but a wise investment.

We saved our first crop of alfalfa by drying while our neighbors lost theirs, due to bad weather.

I can assure you, we are very happy with our Cropmaster.

Yours very sincerely,

(signed) E. A. Bodeker  
Waverly, Iowa

The Lennox Furnace Company

Gentlemen:

We wish to inform you that we are very well pleased with our Lennox Cropmaster. We like it because it is well constructed, easy to install and operate, and the oil burner has very clean combustion.

This year we used the Cropmaster on our hay crop. We dried baled alfalfa and also chopped hay. It is as green as the day we mowed it. This hay tested 18.5% protein and has over 37,000 units of carotene per pound. The cost to dry a ton of this hay was \$1.65. This included fuel and electricity. I can hardly wait until we start feeding this hay to my herd of registered Jerseys this winter. This is the best hay that we ever made on our farm. We must say that by using our Lennox Cropmaster with heat we were able to dry 24 hours per day—something that we have not been able to do before with just a fan and motor.

We also dried 3500 bushels of ear corn with the Cropmaster from 23% down to 15% moisture content. By doing so, we were able to get our wheat planted earlier.

The hay made with the Lennox Cropmaster will put dollars onto our milk check this winter. I am surely glad that we chose a Lennox Cropmaster when we decided on a heated air dryer this spring.

Yours very truly

(signed) Ray Wetherell  
Pickerington, Ohio



Notes:

This image shows a single sheet of off-white or cream-colored paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There is no handwriting or other markings on the paper.



